

The Electric Sky, Short-circuited

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Introduction

I was originally directed to Donald E. Scott's book, *The Electric Sky* (Mikamar Publishing, 2006)¹, after finding a reference to the work by young-Earth creationist, Barry Setterfield, on his web site². The reference was an attempt by Setterfield to deflect my criticisms that pulsar timing

¹ There is some evidence of an edition of the book which predates 2006. However, I have yet to find any definitive details on this beyond pre-2006 references to it by third parties, such as Mr. Setterfield.

² Barry Setterfield (<http://www.setterfield.org>) is a young-Earth Creationist (YEC) who claims that a large cosmos (>10 billion light-year radius) can fit in the <10,000 year YEC time-scale if the speed of light was much higher in the not-too-distant past. He attempts reconcile radioisotope dating through the use of separate time-scales for dynamical and atomic processes, with the atomic time 'clocks' (isotope decays, spectral lines) running faster than the dynamical time 'clocks' (pendula, gravitational orbits). The dynamical time is the 'true' time-scale for YECs.

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observations were evidence against his claims of a rapidly decaying speed of light³ by invoking a radically different model of pulsars proposed by Dr. Scott⁴.

The Electric Sky is not the first book I've read on plasma cosmology. I had originally read Eric Lerner's *The Big Bang Never Happened* while in graduate school studying for my Ph.D. in astrophysics. More recently, I've read Anthony Peratt's *Physics of the Plasma Universe* (Springer-Verlag, 1992). I expected something similar to a reasonable, popular-level update to the latest claims of the plasma cosmology crowd. I was unpleasantly surprised as I found I could hardly go 2-3 pages in Scott's book without finding major ridiculous claims.

First, a little aside about Plasma Cosmology⁵. Nobel-Prize winning physicist, Hannes Alfvén, who pioneered the study of plasmas and founded the field of magneto-hydrodynamics (combining electromagnetism and fluid dynamics), is generally regarded as the 'father' of plasma cosmology. The underlying concept is that electromagnetic forces, being much stronger than gravitational forces, control much of the large-scale evolution of the Universe. Alfvén has proposed large-scale circuits of currents flowing along magnetic fields as driving mechanisms in active galaxies. Other plasma cosmology advocates, such as Anthony Peratt have developed physics-based simulations of interacting currents forming structures similar to spiral galaxies. Some aspects of plasma cosmology enjoyed a revival of interest in the 1980s but began to die in the 1990s. This loss of interest was very possibly the result of the all-sky microwave maps of COBE and later WMAP, which exhibited no evidence of radio emission from these galaxy-forming currents.

This review is not to deny the real and significant contributions that the studies of plasmas has had in astronomy. Even a simple search of the literature reveals numerous contributions from Alfvén and others. Solar coronal physics is loaded with references to Alfvén waves and the current "ballerina skirt" model of the interplanetary magnetic field was first suggested by Alfvén. But like all competent scientists, they have had ideas in astrophysics that worked, and ideas that failed. The difference between the successful scientists and the unsuccessful or crank is the latter's continued pursuit of unsupportable claims. Unfortunately, a number of plasma cosmology advocates have fallen into this trap.

But *The Electric Sky* is worse, for it does a poor job of representing the standard plasma cosmology claims of Alfvén and Peratt. Much of Scott's material, particularly the Electric Stars claim, do not appear to be part of Alfvén's cosmology, but part of something far more bizarre

³ Bridgman, W.T. *Issues with Barry Setterfield's Claims of a Rapidly Decaying Speed of Light*. <http://homepage.mac.com/cygnusx1/cdecay/>. 2001, 2006. Since Setterfield's cosmology defines a convenient 'fixed' time-scale with the dynamical time, then orbital and spin periods provide constant 'clocks'. If the signal-travel time to Earth is increasing, it is easy to show that the periods measured for these 'clocks' will undergo significant changes.

⁴ Barry Setterfield. *Problems with Pulsars*. <http://www.setterfield.org/000docs/behaviorzpeapp8.html>

⁵ Wikipedia: Plasma Cosmology. http://en.wikipedia.org/wiki/Plasma_Cosmology

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which is apparently described under the term “Electric Universe”. From what I can tell, the primary difference between the Plasma Cosmology (PC) and Electric Universe (EU) is the latter moves these cosmic electric currents as the energy source of the stars as well as galaxies and invokes more electrical processes in solar system physics, apparently even influencing planetary orbital dynamics. In this piece, I’ll try to focus my comments on Scott’s book and Electric Universe claims more than Plasma Cosmology in general, though such a separation will probably prove impossible. Scott poorly documents his own evidence and models as well as many of his claims about astronomy. I did manage to track down some original references after a detailed search of available literature through the Astrophysics Data System⁶.

In a book so incredibly wrong, it was difficult to write something short. Even this analysis is far longer than I originally expected. This paper is a *subset* of my complaints. I have notes on far more issues than are presented in this monograph. It may be expanded as time and resources permit. Considering how much of this type of bad science is being regurgitated in the Creationist community to support *their* claims, I suspect I will be revisiting some of these issues.

⁶ Astrophysics Data System, <http://adswww.harvard.edu>

The Gamut of Science and Physics Conceptual Failures...

In this section, I'll describe some of the general conceptual errors of how astronomy (and physics) are developed in "The Electric Sky".

Astronomy assumes the Laws of Physics in the Distant Cosmos are different from on Earth.

Dr. Scott states that astronomers assume that the physical laws in the distant cosmos are different from those known on the Earth (page 7). Wrong. The default assumption is that the laws of are identical on the Earth and in distant space. This concept dates back to Galileo in 1592. The appearance of a difference can arise because some measurements may not currently be possible in Earth laboratories. The vacuum between stars is still less dense than the best vacuum possible in the laboratory. There are some searches for Dark Matter and Dark energy candidates that are being conducted in Earth laboratories.

Astronomy has made no contributions to fundamental science

Scott claims that astronomy has made no contributions to fundamental science or is not really testable (pages 4, 5, 7, 9). Consider his statement on page 4:

“The answer is because there are no tangible, usable products from which we can judge the validity of theories emanating from sciences that deal with events that happened long, long ago and far, far away.”

Scott ignores many examples in the history of science where processes were discovered from astrophysical evidence years before they could be reproduced in the laboratory. For example, Scott mentions “forbidden lines” (page 166) in atomic spectra, but never mentions that these lines were first reported in planetary nebulae in 1868 and defied explanation for years until the quantum mechanical explanation was found in 1927. It would be a few years later, 1931, before they were reproduced in Earth laboratories. He praises useful technologies such as the GPS, but ignores how general relativity, initially only used in cosmology, must be used in computing the time of flight of the GPS radio signals in the gravitational field of the Earth to nanosecond precision necessary for the computation to yield useful results⁷. I have also recently completed an article on the astrophysical origins of some of the science behind our technology⁸.

Theory vs. Laboratory validation

Another mistake Scott makes is an almost dogmatic adherence to the notion that if it hasn't been demonstrated in the laboratory or tested in situ, then it can't be real (page 9, 19). He ignores the fact that many things we know today, not just in astrophysics, were predicted theoretically, years,

⁷ Ashby, Neil. *Relativity in the Global Positioning System*. 2007. <http://relativity.livingreviews.org/Articles/lrr-2003-1/>

⁸ “[The Cosmos In Your Pocket: How Cosmological Science Became Earth Technology. I.](#)” W.T. Bridgman, 2007.

and sometimes decades, before they could be demonstrated in the laboratory. As we shall see in later sections, Dr. Scott can be selective about the laboratory evidence as well, only believing it when it is convenient to his argument.

As an example, consider that the existence of the neutrino was originally postulated in 1930 by Wolfgang Pauli⁹, in an attempt to salvage Conservation of Energy in nuclear beta-decays which seemed to violate this principle. This theoretical particle was subsequently incorporated into the computational models of the weak nuclear interaction by Enrico Fermi in 1934¹⁰, where it was successfully used to study components of weak interactions that we *could* measure. It was treated as a real particle for years before its direct experimental detection in 1956¹¹.

We have yet to detect virtual photons in the laboratory, yet their effects can be measured: the Casimir force. We have not actually seen atoms, electrons, protons, photons or other subatomic particles, but we infer their existence from their effects and agreement with detailed *mathematical models* of their behavior.

Dr. Scott conveniently forgets that Newton's theory of Gravity was not tested *in situ* until the launch of artificial satellites in 1957. Previous uses of the theory to determine the value of the Newtonian gravitational constant, G , always assumed the $1/r^2$ dependence! Laboratory-scale tests of Newton's $1/r^2$ force were not actually performed until the 1970s¹². Even then, the initial measurements were so fraught with errors there was speculation that a “fifth force” was involved.

There are numerous similar examples in the history of science.

The Importance of *in situ* Measurements

Related to the laboratory validation issue is Dr. Scott's repeated statements that astrophysical claims can't be tested since *in situ* measurements are not possible (pages 9, 19) and this means that all kinds of other claims should be admitted on equal footing. Though I've yet to find an actual historical reference, I would not be surprised if a similar argument wasn't leveled at Galileo, when he claimed the planets were actually other worlds; or Newton, when he claimed the force that holds the planets in orbit around the Sun was the same as that acting on earth-bound falling objects. After all, in their day, the possibility of *in situ* measurements was the stuff of fiction. We can't do *in situ* measurements on the constituent particles of atoms either, but a successful theory makes testable predictions in other ways. Dr. Scott clearly does not recognize this.

⁹ Pauli, W. 1930

¹⁰ E. Fermi, *Versuch einer Theorie der β -Strahlen. I.*, Zeitschrift für Physik, 88 (1934), pp. 161–177.

¹¹ C. L. Cowan, Jr., F. Reines, F. B. Harrison, H. W. Kruse, and A. D. McGuire, *Detection of the Free Neutrino: A Confirmation*, Science, 124 (1956), pp. 103–104.

¹² D. R. Long, *Why do we believe Newtonian gravitation at laboratory dimensions?*, Physical Review D, 9 (1974), pp. 850–852.

Logic: The Formal System vs. Systematized Human Prejudices

Dr. Scott often invokes the *logic* of his explanations over those of mainstream astronomy, stating that a theory must be “logical and reasonable” (page 226) and should not involve counterintuitive ideas (page 6). Yet he confuses the formal mathematical concept of logic, used in deriving theorems and similar mathematical results, with the set of human constructions we sometimes call ‘logic’, most commonly applied in legal issues (Creationists invoke this trick as well). Yet the history of science demonstrates that this forcing of the human construction when applied to the physical world can easily lead one astray.

In Zeno’s ‘logic’, Achilles can never catch up with the tortoise, even though by experiment, he does!

Aristotle argued that objects fall to Earth because it is the center of the Universe and it is ‘natural’ for them to fall thus. Geocentrism is firmly entrenched in this ‘logic’. He also used logic to claim that heavier objects fall faster than lighter objects. That these fallacies held for nearly 2000 years, in spite of the simplicity of some actual tests, is a testament to how easily people can be deceived by these arguments.

If you examine the ‘guiding principles’ of many of the ‘non-mainstream’ journals, such as the “Journal of Theoretics”, they explicitly state that logic, or at least their interpretation of logic, drives their science.

Today, our technologies rely on many underlying theories, such as quantum mechanics and the special and general theories of relativity, that defied the human definitions of “logic”. You will find many a crank on the Internet using the “illogic” of these theories as evidence for their specific interpretation. Yet in spite of the “illogic” of the science, it produces technologies that work!

Trusting Mathematical Models

Dr. Scott complains about trusting mathematical models (page 25). Yet it is these mathematical models which provide numerical predictions for testing hypotheses. They not only provide insights for phenomena far away, but they enable us to ‘see’ things, such as atoms and subatomic particles, which are impossible to see.

Mathematical models provide a practical means of determining the properties of products before they are actually built, potentially saving money. Aircraft used to be built and you didn’t know if they would fly until someone actually flew them. Later, wind tunnel testing was used to supplement the simple mathematical models of aerodynamics, enabling new designs to be tested before the expense of actual full-scale construction. While the Navier-Stokes equations of fluid motions have been known for over a century, solving them for flows over any realistic complex surface were too computationally complex for the tools of the day. The development of modern computers has since enabled us to generate reliable solutions for the more complex physical systems. These mathematical models now enable us to design aircraft entirely on a computer before the first piece of material is cut, providing even more cost savings.

It Looks like 'X' so it must be 'X'

Dr. Scott invokes electric currents as the underlying descriptions of many phenomena due strictly to their appearance. He does this for the Helix nebula (page 61), the Grand Canyon (page 135), terracing in craters (page 140), and many others.

This is another common fallacy. It is an easy trap because many similarities between structures in radically different environments are not because they are driven by similar fundamental processes, but because the different fundamental processes have very similar mathematical forms and therefore their 'equations of motion' yield similar results.

Scott claims that the Grand Canyon has a shape like a Lichtenberg pattern created by electron dislocations in crystals (page 135). However, the Mississippi River exhibits a similar fractal-like pattern. Is he claiming that it too was carved by giant electrical arcs? Even Mark Twain, during his time as a riverboat captain described in "Life on the Mississippi", noted how the river course would change, with no reports of giant electric arcs.

Reliance on Anomalous Observations

Like many creationists and other crank scientists, Dr. Scott tries to tap almost every astronomical anomaly as evidence of his claims. The problem with these types of approaches is that almost all the crank explanations are different. One is stuck with the problem of whom to believe, the standard cosmology which has several thousand trained professionals in agreement, or the anomaly cosmologies which are as different as the number of advocates!

It is true that anomalies generate news. This is because virtually all new science started as what appeared to be an anomaly. However, the converse is not always true, that all anomalies started new science. Very often, the anomaly can be the result of a missing piece of information in the model, or familiar physics in unfamiliar conditions.

The simple fact is that NO amount of anomalies in Theory A make Theory B defacto correct. The real answer might be a Theory C that has yet to be developed. Theory B must not only make specific predictions on the anomaly, but must also be consistent with other observations as well. Creationists and other crank scientists make this error repeatedly.

Just plain silliness...

Scott manages to start with his misunderstanding of some issue in astronomy and proceeds to rant about it. If there were an Emily Litella¹³ award in astronomy, he is a "Never mind" away from being a prime candidate.

Dr. Scott repeatedly tells stories of asking an astronomer some question and obtaining an odd, or in some cases outright wrong answer (page 95, 119, 165, 210). Since he doesn't report who makes these statements, we can't really assess the quality of the answer. Astronomy, like so many other fields, has become highly specialized. Asking an observational astronomer a question outside his field, such as nuclear astrophysics, one can often get a response that is

¹³ Wikipedia: Emily Litella. http://en.wikipedia.org/wiki/Emily_Litella

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anywhere from wrong to ridiculous. Some of these errors may relate to the state of the knowledge at the time the astronomer was in graduate school, perhaps 30 years earlier! Astrophysics has become so complex and specialized, that having a good general knowledge of the latest developments in the field is very difficult.

Dr. Scott, an electrical engineer, is clearly a victim of this professional isolation himself. I found little mention of quantum mechanics or its impact in astronomical observations and astrophysical understanding and the feedback astrophysics provided to Earth laboratories. Considering that the quantum mechanics that explains the spectra and energy source of the stars is the same quantum mechanics that has made modern microelectronics possible, I suspect Dr. Scott probably has some interesting misconceptions about this subspecialty of his own field.

Science That Dr. Scott Just Gets Wrong...

In this section, the longest of this paper, I'll describe just *some* specific scientific errors that Dr. Scott makes. A full accounting would probably be longer than *The Electric Sky* itself!

Albert Einstein: Theoretician

Dr. Scott states that Einstein only did thought experiments, not actual experiments and that this deductive approach makes theories impossible to falsify (page 23). Technically true, but many others would perform the experiments that validated relativity¹⁴. What Scott doesn't tell you is that James Clerk Maxwell, whom Scott praises for the work unifying electricity and magnetism in 1861, was *also* a theorist. It would fall to experimentalists such as Heinrich Hertz to actually validate some of ideas from Maxwell's merging of electricity and magnetism.

Gravitational Lensing was the FIRST big test of General Relativity!

Dr. Scott describes gravitational lensing as untested (page 33). Yet gravitational lensing was one of the first observational tests of general relativity, under its earlier name, the gravitational deflection of starlight by Sun. It was first reported from an expedition by Arthur Eddington in 1919¹⁵ and has been retested as new technologies with increasing precision became available. More recently, it has been tested in communications with interplanetary spacecraft and in the Hipparcos astrometry mission¹⁶.

General Relativity Does Include Electromagnetism

Scott claims there are no electromagnetism effects in general relativity (page 218). This suggests he has never actually examined a textbook on general relativity. There are sections covering the topic in Misner, Thorne, and Wheeler's *Gravitation*¹⁷; Adler, Bazin, and Schiffer's *Introduction to General Relativity, 2nd Edition*¹⁸; and others. In books on general relativity, electromagnetism is usually covered as an introduction to the concept of tensor fields with additional aspects of the field with gravity developed from there

We also note that the Schwarzschild metric, the metric around a non-rotating mass, has a charged solution, the Reissner-Nordstrom metric. The rotating mass solution, the Kerr metric, also has a charged Kerr-Newman metric solution. If General Relativity didn't include electromagnetism as Dr. Scott claims, how would this be possible?

¹⁴ C. M. Will, *The confrontation between general relativity and experiment*, Living Reviews in Relativity, 9 (2006). <http://relativity.livingreviews.org/Articles/lrr-2006-3/>

¹⁵ A. Eddington, 1919

¹⁶ M. Froeschlé, F. Mignard, and F. Arenou, Determination of the ppm parameter γ with the hipparcos data, in Proceedings from the Hipparcos Venice '97 Symposium, Noordwijk, Netherlands, 1997, ESA.

¹⁷ C. Misner, K. Thorne, J. Wheeler. *Gravitation*. pg 568-570

¹⁸ R. Adler, Bazin, Schiffer. *Introduction to General Relativity*. Chapter 15.

Naked Singularities are NOT Black Holes

On page 15 of *The Electric Sky*, Dr. Scott quotes physicist John Wheeler of UT Austin:

“To me, the formation of a naked singularity [a black hole] is equivalent to jumping across the Gulf of Mexico. I would be willing to be a million dollars that it can’t be done. But I can’t prove that it can’t be done.”

This immediately caught my attention as a possible altered quote. Anyone familiar with the subject knows that a naked singularity is *not* the same as a black hole. John Wheeler would definitely know this. A black hole is a singularity ‘clothed’ in an event horizon. I found what appears to be the original quotation in a New York Times story from 1991¹⁹. The ‘clarification’ of ‘[a black hole]’ does not appear in the article, which suggests this alteration was done by Dr. Scott. The original article described the results of numerical modeling a gravitational collapse where a naked singularity formed instead of a black hole. This would be a violation of the Cosmic Censorship Hypothesis whereby it is believed, *but not proven*, that naked singularities cannot form in Nature²⁰. The possible violation of this hypothesis was the reason for Wheeler’s statement.

Dr. Scott not only doesn’t show the source of the quote, but he does not indicate his alteration of it. He proceeds to use this misunderstanding of the quote to essentially claim that astronomers just make stuff up:

“What he is actually saying is - **YOU** can’t prove that black holes don’t exist, so **I** am free to use the concept as often as I like.”(page 15).

Outflows from Accreting Black Holes are NOT Hawking Radiation

Dr. Scott mistakes polar outflows from accreting black holes as a manifestation of Hawking radiation (pp 212-213) when it is actually a characteristic of accretion disks. Similar outflows are observed in accretion in star formation regions. Hawking radiation is a quantum phenomenon which is only significant for *very* small black holes²¹.

Gravity vs. Electricity

Dr. Scott makes a very strange point about how Newton's law of gravity works for objects on the Earth and launching satellites (page 27). By only mentioning these two processes, is he denying that it operates in the rest of the Solar System? Is he claiming that there could be significant electrostatic forces operating between the other objects in the solar system? In this era of precision astrometry, where we can compute the motions of planets and asteroids decades into the future and generate precision predictions of eclipses, such additional forces would significantly alter the reliability of those predictions.

¹⁹ “[Computer Defies Einstein’s Theory](#)” John Noble Wilford. New York Times, March 10, 1991.

²⁰ Wikipedia: Cosmic Censorship Hypothesis. http://en.wikipedia.org/wiki/Cosmic_censorship_hypothesis

²¹ Wikipedia: Hawking Radiation. http://en.wikipedia.org/wiki/Hawking_radiation

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While there are “error bars” on these predictions, they fall well within the bounds prescribed by gravitational forces and measuring techniques. Dr. Scott obviously hasn’t examined even the simplest models based on this idea. Even funnier is that I’m writing this the day after the passage of asteroid 2007 TU24 near the Earth, and there have been no natural disasters incited by electrical discharges between the Earth and the asteroid as predicted by some EU advocates²².

In the next paragraph, he claims that Newton’s laws don’t apply in the nucleus of the atom because it is overpowered by the strong and weak nuclear forces. Actually, the problem at the atomic level is that the quantum mechanical effects of the wave nature of matter, not the forces *per se*, become significant. This alters the equations of motion for sub-atomic systems. Dr. Scott doesn’t seem to know that the fundamental forces, such as the Coulomb potential, appear in quantum theory in almost the same mathematical form as they appear in macroscopic physics. Even fewer people recognize that applying the expectation values to the Schrodinger wave equation yields Newton’s Second Law, $F = ma$!

Even stranger is after claiming that electric forces can produce the huge quantities of energies needed for some astrophysical processes, he later implies that these forces will also explain the Pioneer anomaly (page 148). This is an effect so tiny that there is still some debate as to whether the effect is real and not the result of some overlooked systematic error introduced during the over 30 years since launch!

Solar and Nuclear Energy Errors

Dr. Scott denies that nuclear fusion, specifically the proton-proton chain, can be the energy source for the Sun and other stars. The most bizarre part of this claim is his statement that Arthur Eddington intimidated other researchers from questioning nuclear reactions as the source of stellar energy (page 47). Scott also makes a bogus analogy between solar nuclear power and how nuclear weapons operate and the failure to achieve self-sustaining fusion reactions on the Earth. He clearly does not understand the relation between temperature, pressure, and reaction cross-sections that are important in nuclear reactions.

In the case of a nuclear device, you have at the initial reaction site a plasma at very high temperature and pressure, surrounded by the Earth’s atmosphere at a much lower temperature and pressure. The reaction can shut down for two reasons:

1. all of the reactants are consumed, or
2. as the hot plasma expands and cools, the density is no longer sufficiently high to maintain the reaction rate of any remaining reacting material. The reaction rate is proportional to the product of the density of the two reactants.

²² “Asteroid 2007 TU24. No Danger to Earth.” Bad Astronomy, January 25, 2008, <http://www.badastronomy.com/bablog/2008/01/25/asteroid-2007-tu24-no-danger-to-earth/>

In the case of the Sun, neither of these conditions is a problem. There is plenty of reaction material (another five billion years worth at current consumption rates) and the material outside the reaction site has its pressure maintained by being at the bottom of nearly 700,000 kilometer deep mass of hydrogen and helium. Under these circumstances, the hydrostatic pressure, as we see in Figure 1, is about 10^{17} dynes/cm², or about 10^{11} (100 billion) atmospheres.

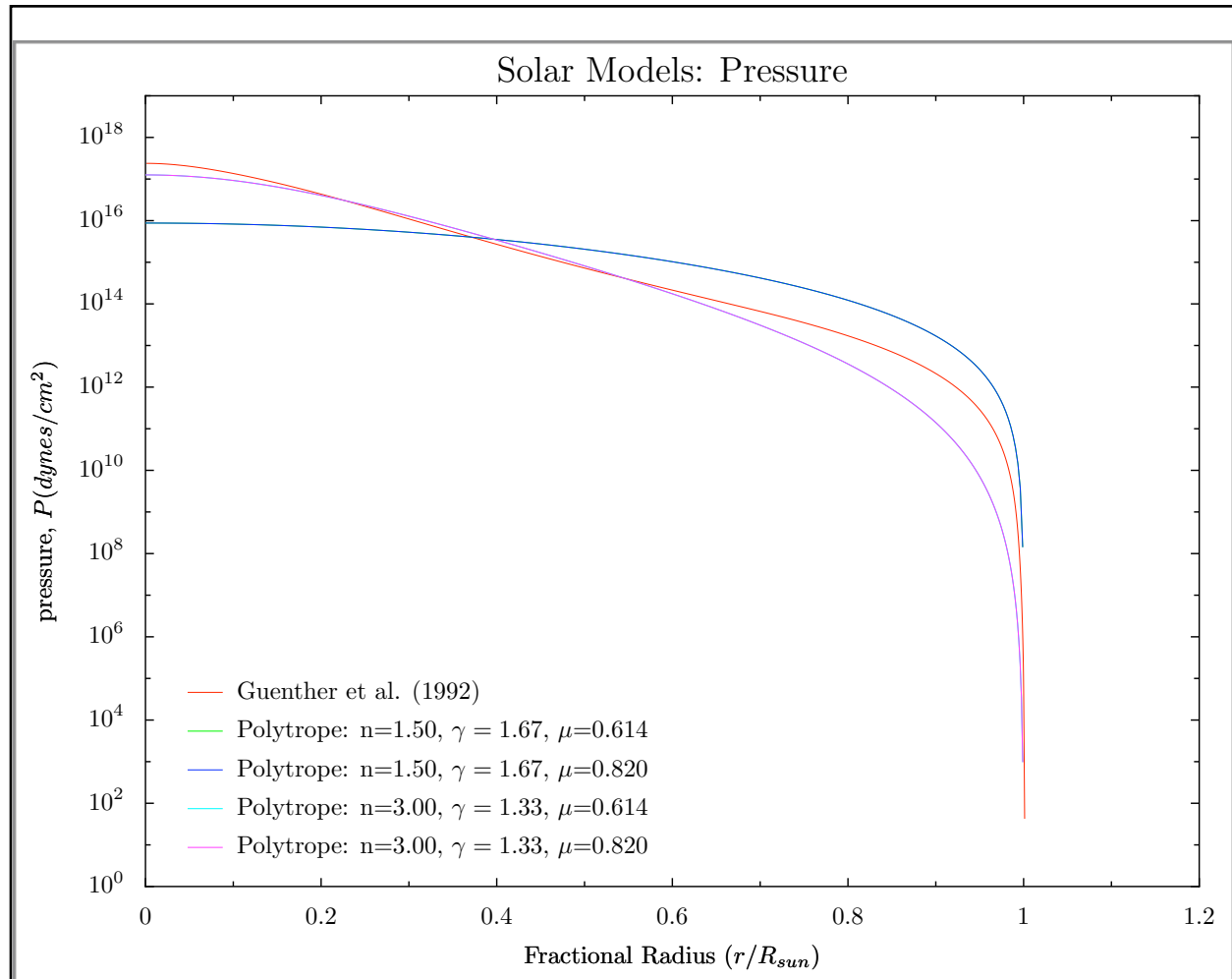


Figure 1: Computational Stellar Models

This plot compares the pressure vs. radius relation of a modern computational solar model (Guenther et al. 1992) to the simple polytrope models computable in the early 20th century. Polytropes are computed with the simple assumptions of hydrostatic balance under self-gravitation and an adiabatic, ideal gas, equation of state. These types of models were the 'state of the art' in the pre-computer days of 1920! Today they can be computed in seconds on any commercially available computer. [Plot by the Author]

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Of all the nuclear reactions in the proton-proton chain, only the first step, $p + p \rightarrow d + e^+ + \nu_e$, has NOT been observed in the laboratory, though only a few have been observed at energies as low as those in stellar interiors (15 million degrees K \sim 1 kiloelectron volt). This is largely due to the high beam densities need to achieve a measurable reaction rate.^{23,24}

Scott also apparently doesn't realize that the solution to the proton-proton reaction, discovered by Bethe and Critchfield in 1938²⁵, uses the same quantum-mechanical tunneling effect that made the tunnel diode possible nearly 20 years later. He ignores the fact that for stellar interior physics, the relationship between reactant energies and density, is virtually identical to that used in development of nuclear weapons (a fact that may be relevant to why the United States was successful in these efforts). The interested reader can compare the reaction and radiation transport equations in a graduate-level stellar structure and evolution textbook with information on the same topics available in the Nuclear Weapons FAQ²⁶. Hans Bethe, as well as Edward Teller, were involved in significant research before World War II exploring the connection between nuclear physics and stellar energy sources. It is no coincidence that they would both become significant players in the development of nuclear weapons.

Another interesting historical note is that at the time of the 1939 "Einstein Letter" advocating the development of the atomic bomb, there was no laboratory evidence that such a weapon would work, that the nuclear physics in the laboratory would actually extrapolate to the conditions needed for a bomb. The best evidence that our understanding of nuclear physics was sufficiently complete for the problem was Hans Bethe's work on the stellar proton-proton chain the previous year.

Missing Neutrinos

Dr. Scott devotes an entire chapter (pages 47-52) to his interpretation (or misinterpretation) of the neutrino results and the implications for the Electric Star model. He starts by parsing a sentence from the SNO press report (page 49)

"If neutrinos from the Sun change into other active flavors, the CC flux will be less than the ES flux."

²³ G. Bogaert, *Nuclear reactions in the stars and in the laboratory*, Acta Physica Polonica B, 31 (2000), pp. 299–309.

²⁴ E. G. Adelberger, S. M. Austin, J. N. Bahcall, A. B. Balantekin, G. Bogaert, L. S. Brown, L. Buchmann, F. E. Cecil, A. E. Champagne, L. de Braekeleer, C. A. Duba, S. R. Elliott, S. J. Freedman, M. Gai, G. Goldring, C. R. Gould, A. Gruzinov, W. C. Haxton, K. M. Heeger, E. Henley, C. W. Johnson, M. Kamionkowski, R. W. Kavanagh, S. E. Koonin, K. Kubodera, K. Langanke, T. Motobayashi, V. Pandharipande, P. Parker, R. G. Robertson, C. Rolfs, R. F. Sawyer, N. Shaviv, T. D. Shoppa, K. A. Snover, E. Swanson, R. E. Tribble, S. Turck-Chi`eze, and J. F. Wilkerson, *Solar fusion cross sections*, Reviews of Modern Physics, 70 (1998), pp. 1265–1291.

²⁵ H. A. Bethe and C. L. Critchfield, *On the formation of deuterons by proton combination*, Physical Review, 54 (1938), pp. 862–862.

²⁶ Nuclear Weapons FAQ. <http://nuclearweaponarchive.org/Nwfaq/Nfaq0.html>

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He parses it from the perspective that even if “the CC flux will be less than the ES flux” is always true, it does not imply that “neutrinos from the Sun change into other active flavor” is true. Logically correct, if one examines *only this experiment*. In combination with results of other previous experiments, such as the evidence of solar neutrinos changing flavor as they pass through the Earth, then the interpretation has the highest probability of being true.

Of course, if physicists and astrophysicists are as clueless and corrupt as Dr. Scott tries to present them, the questions would not even have been tested this far. Unfortunately for Dr. Scott, physicists continued to improve the experiments to more definitively answer the questions. While Dr. Scott alludes to upcoming experiments in this chapter (page 50), the experiments were actually completed in 2003, three years prior to the publication of this edition of *The Electric Sky*. The KamLAND experiment actually measured neutrino oscillations from a reactor on the other side of the Earth and additional measurements were conducted along the path to calibrate the content of the source beam^{27,28}.

Did Dr. Scott assume that no one would question his ‘authority’ on the subject and went ahead with the book’s publication in spite of the fact that this result implied the book would require extensive revision? This is the charge Dr. Scott makes against Arthur Eddington on page 47 in regards to hydrogen fusion. Then again, Dr. Scott could have just been careless in his research.

Dr. Scott tries to fall back on the claim that we can’t really know the actual source neutrino flux from the center of the Sun (page 48). However, his argument applies to every technology of a similar nature such as radiation therapy. We compute the flux of photons or neutrons or whatever particle of interest based on principles that have been firmly established in the laboratory.

While we often speak of the 15 million degree temperature at the center of the Sun (original estimates were computed using the polytrope models plotted above), the mean energy of the particles are actually low compared to the energies achieved in modern particle accelerators such as at CERN and FermiLab. If you want to argue that you can’t know what is happening in the center of the Sun, you have to deny, at minimum, many laboratory-established physical principles that are used to compute these properties, such as:

- Hydrostatic pressure: The weight (and pressure) of the overlying matter increases in a fluid subject to gravity. This is the same ‘increasing pressure with depth’ that underwater divers are very familiar with. This self-gravity force also acts to hold the star together.
- Ideal Gas Laws: The bulk of the Sun, especially in the center, is at a sufficiently high temperature for complete ionization of all but the innermost electrons of the highest-Z

²⁷ Eguchi et al. *First Results from KamLAND: Evidence for Reactor Antineutrino Disappearance*. Physical Review 90, 21803. (2003)

²⁸ K. M. Heeger, *Evidence for Neutrino Mass: A Decade of Discovery*, ArXiv High Energy Physics - Experiment e-prints, (2004).

elements. Gas pressure is what keeps stars from collapsing under gravity through most of their life. Apparently Dr. Scott doesn't understand this since he actually has to ask what keeps stars from collapsing (pp 98-99)!

- Nuclear Physics: Principles for computing nuclear reaction rates are well-established in laboratories and weapon systems.
- Quantum tunneling: This is the same process important in the operation of the tunnel diode and cold-cathode/field-effect emission. While important for a number of other stellar nuclear reactions, it is vital for computing the $p + p \rightarrow d + e^+ + \nu_e$ reaction rate.
- Baryon and Lepton number conservation.

So which of these processes does Dr. Scott deny functions in the center of the Sun? What is his laboratory justification?

In addition to the comments about what holds the Sun up, Dr. Scott describes a dipole model proposed by Wallace Thornhill (page 99). It's an interesting idea about 70 years late. The idea was examined in the 1920s by Pannekoek²⁹ and Rosseland³⁰. Rosseland in particular explored possible polarization effects due to gravitational settling of the heavy ions from the light electrons. They demonstrated that any charge separation would produce an electric field which would quickly drive the volume back to charge neutrality. The net result generated a *small* positive charge on the Sun surrounded by a cloud of light electrons maintaining overall electrical neutrality. The final conclusion was that the ideal gas laws remained the dominant influence. Even my Ph.D. advisor would occasionally point out that stars were effectively held up by the electrostatic repulsion of the ions and electrons and these works are the source of that. A few years later, Irving Langmuir would conduct a similar analysis of separating charges in a plasma and derive an oscillatory time scale, today called the plasma frequency³¹. This Pannekoek-Rosseland field has even been explored as a driving mechanism for stellar winds under some very specific conditions.³²

Nuclear Reactions in Solar Flares

Scott tries to explain the presence of helium on the Sun by invoking hydrogen-to-helium fusion in places like solar flares(pages 105-106). Part of his justification goes back to some reports of

²⁹ A. Pannekoek, *Ionization in stellar atmospheres (Errata: 2 24)*, Bulletin of the Astronomical Institutes of the Netherlands, 1 (1922), pp. 107–118.

³⁰ S. Rosseland, *Electrical state of a star*, Monthly Notices of the Royal Astronomical Society, 84 (1924), pp. 720–728.

³¹ I. Langmuir, *Oscillations in Ionized Gases*, Proceedings of the National Academy of Science, 14 (1928), pp. 627–637.

³² C. Alcock, *The surface chemistry of stars. III - The electric field of a chemically inhomogeneous star*, 242 (1980), pp. 710–722.

correlation of neutrino fluxes with sunspot numbers(pages 106-107) and statements about the detection of helium near sunspots (page 109).

Early neutrino experiments had error bars sufficiently large that false correlations with sunspot number were possible, but it is important to note that these correlations are very weak in regard to the overall neutrino flux. They are so weak, that Walther demonstrates how some statistical tests can produce a similar correlation between random data and data with a strong time dependence³³. While this does not rule out a correlation between solar activity and the neutrino flux, the data suggest that if the correlation is real, it is very weak, no where near enough to move neutrino generating reactions to active solar regions. In addition, if there is a correlation with the solar magnetic cycle, this has interpretations consistent with the existing solar models if the neutrino has a magnetic moment (which is still an open question).

I've yet to find the reference of Dr. Scott's claim of helium detected near sunspots. Neither the helium atom nor helium ion has spectral lines significant at photospheric temperatures so we don't see helium in the photosphere in thermal equilibrium. Active regions and other areas not in thermal equilibrium is another matter. SOHO/EIT as well as the EUVI instruments on STEREO actively image in the wavelengths of some helium lines (30.4 nanometers). Helioseismology measurements and solar models suggest the Sun is about 9% helium (by particle count), so in any region where the spectral state can be excited, like the corona and active regions, we would expect to see it. Why would we consider helium near sunspots a surprise?³⁴

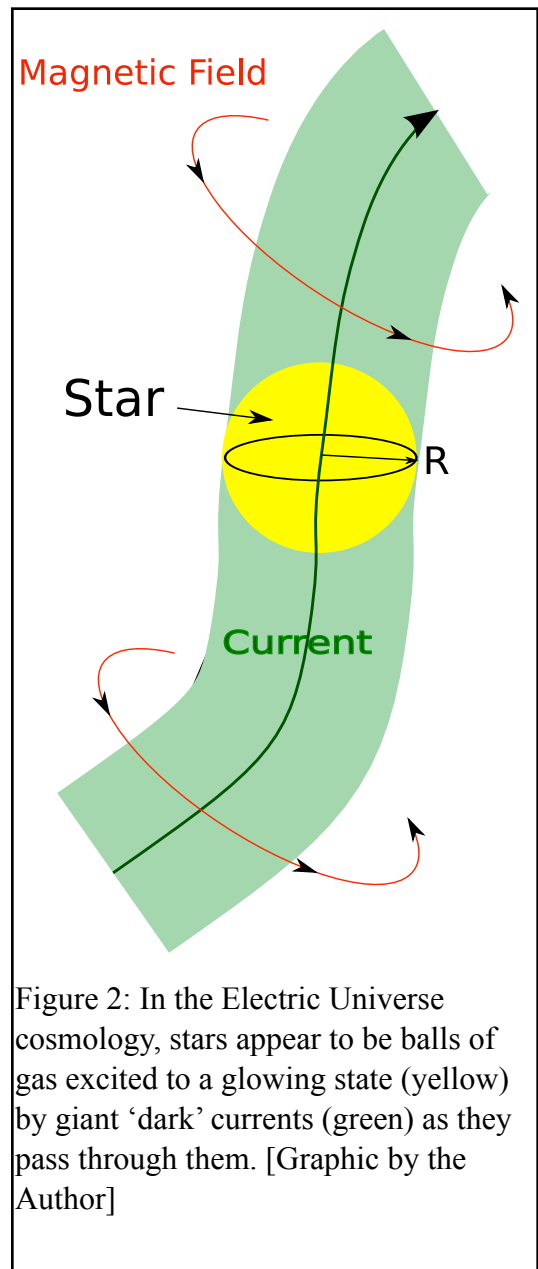


Figure 2: In the Electric Universe cosmology, stars appear to be balls of gas excited to a glowing state (yellow) by giant 'dark' currents (green) as they pass through them. [Graphic by the Author]

³³ G. Walther, *Absence of Correlation between the Solar Neutrino Flux and the Sunspot Number*, Physical Review Letters, 79 (1997), pp. 4522–4524.

³⁴ We can't detect helium in the solar photosphere by spectroscopic means because the thermal energy available at 5800K (mean energy of about 0.5 electron volts) is not high enough to excite the helium atoms or ions to the next available state. The energy gap from the ground state (1s) to the lowest excited energy state (2s) is about 20 electron volts. These helium states could be excited in an active region where the necessary energy is available. We can see the helium spectrum in laboratory gas discharge tubes because they are driven by electron collisions at about 5000 electron volts.

The fusion of hydrogen to helium is a multi-stage process, where all but the $p + p \rightarrow d$ reaction is the slowest in the sequence due to the *extremely* small reaction cross-section. If Dr. Scott wants to claim helium production by a 4-body collision between protons, he should demonstrate the details of the process, *with reaction rates*. Even an examination of Juergen's paper lacked details of the process³⁵. It contained only the hyped press reports and 'logic' argument regurgitated by Dr. Scott. I can find no evidence that anyone in the Electric Universe community has computed the reaction rates to support this claim.

There is observational evidence that deuterium can be formed in solar flares through the reaction $p + n \rightarrow d + \gamma$. This is determined through observation of a gamma-ray line at 2.2MeV which is characteristic of neutron capture on protons³⁶. There are signatures of a number of other nuclear reactions detected in the X- and gamma-ray spectra of solar flares³⁷. However, the intensity of these events is insufficient to explain the solar abundances of the heavy elements. The ES community has provided no experimental or theoretical reason why these nuclear reaction rates might be incorrect.

Powering the Sun from the Outside

If the Sun is not powered by internal nuclear reactions, then what do the Electric Universe advocates claim to be the real source of the Sun's Energy? Why giant, invisible, electric currents, of course! Part of Dr. Scott's justification is that the Ulysses mission measured a current when it travelled over the pole of the Sun (page 98). Interestingly, Dr. Scott does not mention if the measurement was consistent with the current density required by the EU model.

No problem. This claim can actually be examined in the true scientific sense with some very basic physics. How would an astrophysicist evaluate such a model? With this information, a little knowledge of the Sun, and some basic physics, we can make some additional predictions from this model. What would it take to power the Sun electrically?

We can examine the amount of power physically possible for a current of a given electron density and mean energy per electron. The Sun has a radius, R_{Sun} , of 6.96×10^8 meters and a luminosity of 3.827×10^{26} watts.

From the electron kinetic energy, E_{KE} , electron rest mass, m_e , and the speed of light, c , we can compute the velocity, v :

$$v = c (1 - \gamma^{-2})^{1/2} \quad \text{where} \quad \gamma = 1 + (E_{KE}/m_e c^2)$$

³⁵ R. Juergens, *Stellar thermonuclear energy: A false trail?*, KRONOS A Journal of Interdisciplinary Synthesis, 4 (1979), pp. 16–27. <http://www.kronos-press.com/juergens/k0404-stellar.htm>

³⁶ *RHESSI Observes 2.2 MeV Line Emission from a Solar Flare*. <http://svs.gsfc.nasa.gov/goto?2750>

³⁷ M. J. Aschwanden, *Physics of the Solar Corona. An Introduction with Problems and Solutions* (2nd edition), Dec. 2005. pp 610-619.

Table 1: Current requirements for the Electric Sun. Ranges of values that could power the Sun are highlighted in blue.

m^{-3}	eV	v/c	gamma	amps	Tesla	Tesla(1 AU)	W/L _{Sun}
1.00e+10	1.00e+00	0.001978	1.0000	1.45e+15	4.16e-01	1.93e-03	0.00000
1.00e+10	1.00e+03	0.062470	1.0020	4.57e+16	1.31e+01	6.10e-02	0.00000
1.00e+10	1.00e+06	0.941079	2.9570	6.88e+17	1.98e+02	9.20e-01	0.00180
1.00e+10	1.00e+07	0.998818	20.5695	7.30e+17	2.10e+02	9.76e-01	0.01908
1.00e+10	1.00e+08	0.999987	196.6951	7.31e+17	2.10e+02	9.77e-01	0.19100
1.00e+10	1.00e+09	1.000000	1957.9514	7.31e+17	2.10e+02	9.77e-01	1.91003
1.00e+12	1.00e+00	0.001978	1.0000	1.45e+17	4.16e+01	1.93e-01	0.00000
1.00e+12	1.00e+03	0.062470	1.0020	4.57e+18	1.31e+03	6.10e+00	0.00001
1.00e+12	1.00e+06	0.941079	2.9570	6.88e+19	1.98e+04	9.20e+01	0.17975
1.00e+12	1.00e+07	0.998818	20.5695	7.30e+19	2.10e+04	9.76e+01	1.90777
1.00e+12	1.00e+08	0.999987	196.6951	7.31e+19	2.10e+04	9.77e+01	19.10009
1.00e+12	1.00e+09	1.000000	1957.9514	7.31e+19	2.10e+04	9.77e+01	191.00331
1.00e+14	1.00e+00	0.001978	1.0000	1.45e+19	4.16e+03	1.93e+01	0.00000
1.00e+14	1.00e+03	0.062470	1.0020	4.57e+20	1.31e+05	6.10e+02	0.00119
1.00e+14	1.00e+06	0.941079	2.9570	6.88e+21	1.98e+06	9.20e+03	17.97493
1.00e+14	1.00e+07	0.998818	20.5695	7.30e+21	2.10e+06	9.76e+03	190.77748
1.00e+14	1.00e+08	0.999987	196.6951	7.31e+21	2.10e+06	9.77e+03	910.00862

We'll examine a range of energies, up to 109 volts, which is the approximate driving voltage for the Sun advocated by Dr. Scott (pages 91, 96). Using the velocity from above, the electron density, n , and the area of intersection with the Sun, $A = \pi R_{Sun}^2$, we also examine a range of electron densities, computing the electric current, I :

$$I = q n v A \quad \text{amps}$$

where q is the charge of the electron. We can also compute the total power, or the amount of energy passing through this region per unit time. This must be *at least* equal to the solar luminosity:

$$P = E_{KE} n v A \quad \text{watts}$$

Once we know these quantities, we can also compute the strength of the magnetic field produced by this "long-wire" configuration.

$$B = \mu_0 I / 2 \pi r \quad \text{tesla (= 10,000 Gauss)}$$

For a range of electron densities and energy, we construct a table of power available for a star. To further test this model, we'll examine the strength of the magnetic field produced, both at the

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surface of the Sun as well as at the orbit of the Earth (1 AU = 1.49×10^{11} meters). Anyone can examine this with a simple spreadsheet program such as Excel. We tabulate a subset of the results in Table 1.

Examining the results, we notice that when the electron current reaches sufficient energies to power the Sun (highlighted), the magnetic field at the surface of the Sun is on the order of 100 Tesla (1,000,000 Gauss) or more. This is particularly interesting in light of the fact that the *observed* magnetic fields on the surface of the Sun range from 0.01 Tesla (granulation) to 0.2 Tesla (sunspots)³⁸. This is quite a large anomaly (a factor of over 100!) which the Electric Sun advocates neither mention, nor explain.

In addition, their model predicts that the magnetic field at the orbit of the Earth (1 AU) could range between 0.1-10 Tesla (1000-100,000 gauss). This too is far stronger than the field actually measured of a few nano-Tesla (~ 0.000000005 Tesla)³⁹. The ES magnetic field value is also far stronger than the Earth's magnetic field at the surface ($\sim 1/2$ gauss). If such a solar magnetic field existed, it would *greatly* overpower the terrestrial field and would determine just how our compasses point. In this case, the *vector* direction of the solar field would be nearly parallel, or antiparallel, to the motion of the Earth around the Sun. Compass directions would flip with the cycle of day and night!

Clearly, the Electric Sun advocates need to go back to the drawing board. Their hypothesis fails even this simple consistency test which are only a few of the tests that they would need to pass to be considered even a partially viable theory.

An additional problem for the hypothesis of powering the Sun (or any other object in space) by electric currents moving in free space is the stability of the configuration. Virtually every graduate-level textbook on plasma physics talks about the stability problems of currents moving in space without the guidance of a conducting wire. These instabilities, driven by the fact that electromagnetism can be attractive and repulsive, are the primary technical problem in electromagnetic confinement methods for controlled fusion. When confined by a purely attractive force, like gravity, these instabilities become insignificant.

Plasma stability criteria are discussed in Aschwanden⁴⁰, Sturrock⁴¹, Jackson⁴², and Krall & Trivelpiece⁴³. In cases of a long current in free space, the instabilities of interest are called

³⁸ Anthony Peratt, "Physics of the Plasma Universe". pg 19.

³⁹ Thomas Craven, "The Physics of Solar System Plasmas", pg 228.

⁴⁰ M.J. Aschwanden, "Physics of the Solar Corona", Springer, 2006, pp 263-270.

⁴¹ P.A. Sturrock, "Plasma Physics", Cambridge University Press, 1994. Section 15.

⁴² J. D. Jackson, "Classical Electrodynamics, 2nd Edition". Wiley Interscience. 1975. pg 482-485.

⁴³ N. Krall & A. Trivelpiece "Principles of Plasma Physics" San Francisco Press, 1984. pp. 261-263.

‘sausage’ and ‘kink’ instabilities and occur when the azimuthal field (the field induced by the current) is roughly larger than the magnetic field along the length of the current.

In cases where the current is low, the azimuthal field is small and the currents can be stable, as is the case for currents moving along the Earth’s magnetic dipole field. Such large currents powering objects in space would be very unstable, and we would expect stars (and even galaxies) to ‘wink’ on and off as the instabilities move and perhaps disrupt the current. While Dr. Scott does mention the possibility of the current driving the Sun going out (page 184), he does not explore the underlying cause or its other implications.

Dr. Scott mentions that the Ulysses mission has measured a current over the poles of the Sun (page 98) but he makes no statements comparing the currents measured to those required for the Electric Sun. Actually, Ulysses has measured ‘currents’ during the entire course of the mission,

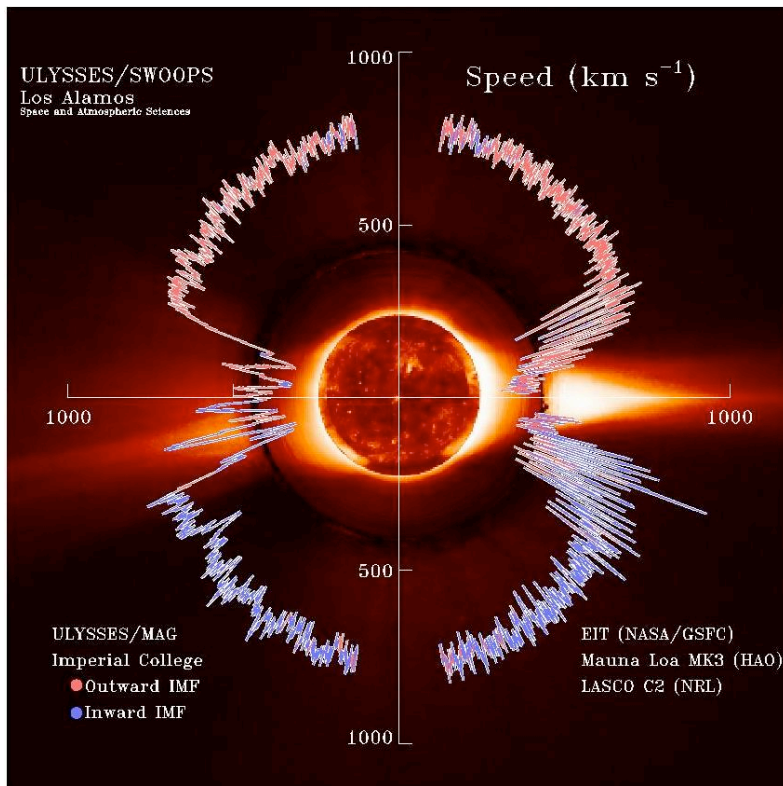


Figure 3: Measurements of the solar wind by the Ulysses mission. Note that all flows are outbound. There is a gap at the solar poles because Ulysses’ orbit is not exactly polar with respect to the Sun. The IMF in the graphic is the direction of the Interplanetary Magnetic Field. [Credit: Ulysses/SWOOPS, Los Alamos]

but the results are inconsistent with the Electric Sun model. Figure 3 is a plot of the measurements of solar wind flow over the course of Ulysses’ mission⁴⁴. Note that over the range of latitudes measured, the solar wind is outbound and varies between 300-800 km/sec. This corresponds to $v/c < 0.0027$, far less than velocities needed to power the Sun computed in the table above. Not only that, but for Electric Sun, one current should be inbound and the other outbound. All Ulysses measurements indicate the flows are all *outbound!*

You could try to eliminate the magnetic field problem by increasing the particle energy while lowering the density. But consider what happens when high-energy electrons strike all that matter. We detect thick-target bremsstrahlung in X-rays near the magnetic footpoints of

⁴⁴ “The Solar Wind”. <http://solarscience.msfc.nasa.gov/SolarWind.shtml>

flaring active regions. We know how quickly electrons decelerate in matter. Beta-rays, high energy electrons from radioactive decay, make it only a few centimeters in air.

If the electron energy exceeds about 1 million electron volts (MeV), electron-positron pairs will form. In a region with lots of matter, like the solar photosphere, the positrons will immediately annihilate with other electrons in the matter. We should therefore see strong emission of photons with energies of about 0.511 MeV from the solar poles. RHESSI has detected this type of emission in solar flares, but not at the poles of the Sun. At higher energies, heavier particles are produced, as we know from laboratory particle beam experiments and cosmic ray showers in the Earth's atmosphere. In this case, Scott must again ignore well-understood aspects of nuclear physics.

Distortions of Helioseismology

Dr. Scott claims that, because we cannot directly 'thump' the Sun, helioseismology cannot probe the solar interior with any degree of confidence (pages 22-23, 97-98). He makes a faulty comparison with seismologists studying earthquakes.

In the case of earthquakes, we actually only obtain measurements at a handful of locations around the Earth, and the equation of state of the Earth's structure is much more complex as materials can have solid and liquid phases within the Earth. In the case of the Sun, we actually have much more data, viewing an entire solar hemisphere. With SOHO/MDI we obtain about 700,000 pixels over an entire hemisphere and the composition is gaseous throughout. This actually makes the solar problem much simpler than the geophysical problem!

Imagine a sphere of water, held together by its surface tension, floating in the space shuttle. If an astronaut nudges this sphere, but not enough to disrupt it, its surface will begin to oscillate and fluctuate. The amplitudes and frequencies of these oscillations are well defined, and if we know the composition of the sphere, we can determine precisely how much energy was imparted to it by the nudge.

In the case of the Sun, while we do not perfectly know some details of the composition, their possible values can be constrained by other measurements which enables the algorithm to find consistent solutions. However, Dr. Scott fails to address other testable predictions made by helioseismology.

One of these predictions, which acts as a consistency check for our understanding, is that using the same physical principles outlined in 'Missing Neutrinos' above, combined with spectroscopic data of solar composition, we can compute the speed of sound in the solar material (a property of the *equation of state* of the material). We can then compare the results to sonic speeds obtained from helioseismology. When comparing these results, *the largest error between the two results is less than one percent! No wonder the Electric Sun advocates don't mention their 100x100 = 10,000% error in their model prediction of the solar magnetic field!*

But even more incredible is that our interpretation of the solar oscillations visible on this side of the Sun enables us to construct a view of the *opposite* side of the Sun. Due to their importance in space weather forecasting (see below), these far-side maps are generated on a regular basis and can be seen at the Space Weather web site⁴⁵. Details of the methodology are available on the SOHO/MDI web site^{46,47}. Visualizations of how this method is tested as the solar rotation carries sunspots to the visible side of the Sun are also available⁴⁸.

Before long, the analysis method will undergo more direct testing as the two STEREO spacecraft move into positions where they can observe the far side of the Sun. While the method is occasionally confused by noise and sampling rate issues, it has proven remarkably robust.

Have the Electric Sun advocates demonstrated any similar capability using their model? I have found no evidence of this.

Miscellaneous solar silliness

Dr. Scott claims that coronal holes almost cover the Sun during solar minimum (page 107). SOHO has observed solar minimum twice and this is demonstrably false, the maximum coverage being about 21 percent⁴⁹. The coronal holes appear as darker regions in ultraviolet (SOHO/EIT) and near solar minimum, are concentrated around the poles of the Sun. Because the data range recorded by the space-based instruments is so much larger than the human eye's response to color, attempts to see details requires the use of different mappings of color to data values. As a result, comparing color-mapped images between solar minimum and maximum can make the Sun appear almost completely dark at minimum. An example of this effect is apparent in the recently published series of solar images and movies over the entire solar cycle⁵⁰.

Dr. Scott states that the standard solar model does not predict the existence of the chromosphere or solar wind (page 83-84). His point being? The gas laws do not predict the existence of the liquid or solid state. What does that tell you? The standard model of the Earth's structure and geology don't predict the Earth's atmosphere, so by Dr. Scott's standards, weather prediction must be impossible. As the density drops near whatever we can call the 'surface' of the Sun, important quantities such as the mean-free-path of the ions and electrons dramatically increase and the approximations suitable to higher density environments like the interior no longer

⁴⁵ Space Weather. <http://www.spaceweather.com>

⁴⁶ "NEW Magnetic maps of the WHOLE Sun". http://soi.stanford.edu/data/full_farside/

⁴⁷ "Acoustic Imaging of the BACKSIDE of the Sun". <http://soi.stanford.edu/press/ssu03-00/backside.html>

⁴⁸ "The Visible Sun Revisited". <http://svs.gsfc.nasa.gov/goto?3336>

⁴⁹ S. A. Chapman and B. J. I. Bromage, *Variation of coronal hole area from solar minimum to maximum using EUV spectroscopic data from SOHO-CDS (preliminary results)*, in *From Solar Min to Max: Half a Solar Cycle with SOHO*, A. Wilson, ed., vol. 508 of ESA Special Publication, June 2002, pp. 383–385.

⁵⁰ "Almost Full Circle in Extreme Ultraviolet" http://sohowww.nascom.nasa.gov/hotshots/2007_12_02/

generate reliable predictions. The present state of the physical knowledge and mathematical techniques require the interior and atmosphere of stars to be treated as separate environments.

Space Weather Modeling

Energetic events on the Sun can generate significant impacts on the Earth. A hundred years ago, the major impact was in the visibility of the aurora and some disturbances in compasses. Today, we know that the particles and fields induced around the Earth by solar energetic events can dramatically impact electronic devices on the Earth and in space. To help protect our growing infrastructure which depends on satellite capabilities, an effort to model and forecast events in “Space Weather” has been developed, supported by civilian and military interests. One such effort is the Community Coordinated Modeling Center (CCMC) at Goddard Space Flight Center⁵¹.

One of the models generated in the space weather effort is the Potential Field Source Surface (PFSS) model. This method constructs a model of the solar magnetic field *above* the surface of the Sun using the boundary condition at the surface provided by regularly generated magnetograms from instruments like SOHO/MDI and Maxwell’s equations⁵². While this is a simple model which does not include even the (relatively) small currents that may exist below the solar surface and in the corona, it often provides the mathematical ‘initialization step’ for more complex models. These models of solar magnetic fields are then compared to coronal loop observations and used for space weather forecasting, such as predicting solar flares⁵³.

These models do not include the huge star-powering currents (and their resulting magnetic fields) of the Electric Sun advocates. If the standard solar model is as wrong as the ES advocates claim, why do these methods work at all?

Plasma physics has made significant contributions in our understanding of the interplanetary, interstellar, and intergalactic environment. Scott emphasizes work of some of the early pioneers such as Birkeland, but he ignores areas where they were found to be wrong. David Stern’s article, “A brief history of magnetospheric physics before the spaceflight era”, describes much of this history⁵⁴.

The Accelerating Solar Wind

Scott claims that the acceleration of the solar wind is a problem for conventional astrophysics and proposes a model based on gas discharge physics. Unfortunately, it seems to be some pretty strange physics. My favorite is his claim that the ions in the solar wind are accelerated outward while the electrons ‘hang around’ (pages 93-95).

⁵¹ Community Coordinated Modeling Center. <http://ccmc.gsfc.nasa.gov/>

⁵² “PFSS - Potential Field Source Surface Solar Model” <http://ccmc.gsfc.nasa.gov/models/PFSS.php>

⁵³ “Space Weather Forecasting”. <http://svs.gsfc.nasa.gov/search/Series/SpaceWeatherForecasting.html>

⁵⁴ D. Stern. "A brief history of magnetospheric physics before the spaceflight era". <http://www.phy6.org/Education/bh1-1.html>

I see two problems with this:

- 1) if the positively-charged ions are being accelerated by an electric field (Scott, Figure 10, page 90), then the negatively-charged electrons must be accelerated in the opposite direction. This is basic physics!
- 2) If the electrons are also being accelerated, due to their lighter mass ($\sim 1/1800$ of a proton), then they are subject to a much higher acceleration (~ 1800 times higher).
- 3) If Dr. Scott claims they're not accelerating, then what magical mechanism keeps them in place? Due to the low density of the corona and solar wind, collision probabilities (i.e. resistance) are low (which is the same as high conductivity in magneto-hydrodynamics terminology).
- 4) If this wind is maintained as Dr. Scott claims, a large charge separation will build up, negative near the Sun, positive in the surrounding region. This will create an additional electrostatic force which will try to bring the charges back together. How long can this process be maintained? I find no mathematical details on this from the Electric Sun advocates.

Dr. Scott also ignores that fact that the acceleration of the solar wind was in fact predicted by E.N. Parker in 1961 by hydrodynamic methods⁵⁵. A steady-state, expanding flow, such as one moving radially outward in a spherical geometry in a gravitational field, will accelerate, moving from subsonic to supersonic in the process. A similar process is exploited in rocket nozzles and wind tunnels to increase the flow velocity (the Laval nozzle). Details of this derivation and comparison of the process are available in Chapter 6, "The Solar Wind", of Cravens' "Physics of Solar System Plasmas"⁵⁶.

Somewhat representative of the problems with plasma cosmology, is the paper by Carlqvist & Alfvén on the solar wind nearly 20 years after Parker's work⁵⁷. The paper is purely descriptive on the subject, gives no mention of Parker's work and the follow-ons nor presents any evidence of why these analyses are wrong. Beyond some global estimates of power, voltage, and amperage, provides no mechanism for further predictions or quantities to compare with other satellite observations.

Crater Formation

Scott claims that craters on the Moon, Mars, and other celestial objects are not formed by impacts, but by giant electric arcs. Part of his evidence is that if they were formed by impacts, we should find more remnants and more elliptical craters (page 138). Yet on the next few pages

⁵⁵ E. N. Parker, *The Stellar-Wind Regions*. *Astrophysical Journal* 134 (1961), pp. 20–+

⁵⁶ Thomas E. Cravens, *Physics of Solar System Plasmas*. Cambridge University Press, 1997.

⁵⁷ P. Carlqvist and H. Alfvén, *Energy source of the solar wind*, *Astrophysics & Space Science*, 71 (1980), pp. 203–209.

(page 140, figure 33), he has a picture with elliptical craters! This claim also ignores a large body of experimental and observational evidence (there are visual sightings of meteor falls) of crater formation by impact. Due to the energy of high-speed impacts, meteors don't 'plow' into the ground. They essentially *explode* on impact. The incoming angle must be *very* shallow for a crater formed by explosions to be elliptical.

The other aspect of this claim, that no remnant of the solid object is found at large crater sites (page 135) can be subjected to a very simple energy budget analysis. To understand the energetics of an impact, consider the simple case of a 1 metric ton iron meteorite impacting at 15 km/sec. I use 15 km/sec since it is a little higher than Earth's escape velocity and it is also the speed an object would have at the surface of the Earth if it fell from an infinite distance under gravity. Depending on relative orbital configurations, the actual speed could be higher or lower. The kinetic energy of an object of mass, m , and speed, v , is $mv^2/2 = 1.1 \times 10^{11}$ joules, equivalent to about 27 tons of TNT. This is 1.1×10^8 joules/kilogram of meteor mass that is dissipated on impact. How will it be dissipated?

Would you expect to find any fragments from the impact of this object? Consider how much energy it would take to warm one kilogram of iron from some low temperature of space (say 10K) to melting temperature (1538K), then heat the molten iron to boiling temperature (2861K), essentially vaporizing the object. With a little work, it is possible to find a number of the required thermodynamic quantities online⁵⁸. The results of these calculations are presented in Table 2.

From this analysis, we see that the energy needed to vaporize the object, 8.2 million joules/kilogram, is less than 10% of the energy available in the impact! With even this rough calculation, there is more than enough energy to vaporize the object on impact. It is not that surprising if we don't find a remnant with a crater for objects that strike at high speeds. The lack of a remnant is not evidence of a different mechanism for crater formation.

There are several loss mechanisms and inefficiencies that can remove the energy going into melting the meteor. Loss due to atmospheric drag has a role, as does the impact energy transferred to the ground. Turbulence during the vaporization process could also enable some fragments to make it out. However, these losses generally increase as the square of the dimension of the object (proportional to the contact area, like atmospheric drag) whereas the energy increases as the cube of the dimension (proportional to the volume, like mass). Therefore, larger and faster objects are *less* likely to leave a remnant than smaller, slower objects.

Another aspect of this question that Dr. Scott completely ignores is that amateur and professional observers have tracked families of Near Earth Objects (NEOs) for many years. Eventually, one of these objects will strike a planet, hopefully not the Earth. If Dr. Scott wants to claim that cratering is not due to impacts of these asteroids and meteors, then he is also implying either

⁵⁸ If anyone can provide more complete data (such as temperature variations of specific heat), I'd be interested in redoing the calculation with the new information, or include it as an exercise.

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1. These objects never strike the Earth or other planets, or
2. If they do strike, they leave no evidence of the impact.

So which is it, Dr. Scott?

Process	Temperature Change (K)	Specific Heat (J/kg/K)	Latent Heat at phase change (J/kg)	Total Energy (J/kg)
Raise temperature from 10K to melting	1538K - 10K	449.00		686x10 ³
Melt the material at constant temperature	0K		247x10 ³	247x10 ³
Raise temperature from melting to boiling	2861K - 1538K	912.00		1207x10 ³
Boil the material at constant temperature	0K		6090x10 ³	6090x10 ³
Total energy requirement for vaporization per kilogram of iron				8230x10³

Table 2: Energy requirements to raise one kilogram of iron from 10 K to its boiling point.

He even claims that crater chains are more easily formed by arcs (page 140) but then talks about comet Shoemaker-Levy 9. This object left a sequence of impacts in the Jovian atmosphere providing an excellent analog of crater chains forming by disrupted asteroids. Here is an example of crater chain formation by impacts in action, yet Dr. Scott seems incapable of recognizing it.

How does the Electric Universe advocates say craters are formed? Again, scarring created by giant electrical arcs. I've found no information from the EU advocates of calculations or estimates on how much energy and voltages or currents are needed to produce 1-100 kilometer-sized craters. How does this compare to the currents and voltages we measure in magnetospheres?

That meteorites create craters has at least been determined in a number of observed falls⁵⁹. To my knowledge, there are no observations of large craters forming by electrical arcs. Can Dr. Scott provide more direct evidence?

⁵⁹ Jarmo Moilanen. "Impacts and meteorites". 2003. <http://www.somerikko.net/old/geo/imp/refer.htm>

Halton Arp & Quasar-Galaxy Associations

Moving into intergalactic space, Dr. Scott taps part of Halton Arp's work on "discordant" redshifts and quasar-galaxy associations. One should note that Dr. Arp is apparently not an Electric Universe advocate, but is a critic of the Big Bang cosmology.

Dr. Scott insinuates that work on the quasar-galaxy associations, such as NGC 4319 and Mrk 205, are being covered up by 'organized' astronomy and specifically, the Space Telescope Science Institute (pages 201-203). Part of his 'evidence' was that the data had become inaccessible and the amateur program under which some of it was collected was cancelled.

Yet I easily found the STSci web page for the observations⁶⁰ and information about the amateur program under which some of it was collected⁶¹. The program was cancelled after 1997 due to budget cuts. The page also links to other resources on the 'controversy'. Apparently STSci didn't get the 'conspiracy memo' to keep the data hidden!⁶² As for the disappearing data, most likely, the data-sets were moved as part of a general archive reorganization which happens time-to-time. These data archives are huge and require continuous upgrading of their technology to meet demands.

I easily downloaded the original data-sets of the observations in FITS format and examined them using the astronomical image analysis package, SAOImage DS9⁶³. I did not perform any of the specialized processing for removing cosmic-ray strikes in the CCD or any field corrections that are part of the standard processing to correct for instrument effects. While it is possible to make the 'connection' appear with convenient choices of color tables, it is also possible to make such 'connections' appear between obviously separated objects, such as the 'black drop' effect observed in transits of Venus and Mercury⁶⁴ and between objects with diffuse edges such as galaxies by judicious choice of isophotes or stair-step color tables⁶⁵. In the case of galaxies, which are large objects with diffuse edges, the overlap of fuzzy edges between two objects increases the amount of light received from the region between them, contributing to the appearance of a connection, whether the objects are connected or not. The real key in these cases is whether there is evidence of *interaction* between the two objects, such as regions of enhanced x-ray emission in the 'bridge' itself.

⁶⁰ Roger Knacke. "The Hubble Heritage Project: NGC 4319 and Markarian 205". <http://heritage.stsci.edu/2002/23/supplemental.html>

⁶¹ Max Mutchler and Harald Schenk. "Amateur Astronomers and the Hubble Space Telescope" <http://www.stsci.edu/~mutchler/amateur.html>

⁶² Yes, I'm being sarcastic.

⁶³ "SAOImage DS9: Astronomical Data Visualization Application". <http://hea-www.harvard.edu/RD/ds9/>

⁶⁴ "Black Drop Effect". Wikipedia. http://en.wikipedia.org/wiki/Black_drop_effect

⁶⁵ The images of NGC 4139 & Mrk 205 were also taken prior to the first Hubble Servicing Mission in December 1993. This is probably the cause of the diffraction-like artifacts around the bright core of Mrk 205 which is visible with some choices of color tables.

The Electric Sky, Short-Circuited

One of the big problems I see with this claim is that if Mrk 205 is actually moving out through the edge of NGC 4319, why don't we see a shock front ahead of it, like we see with many stellar objects moving through the interstellar medium (ISM)⁶⁶? We would expect to see a leading edge of hot gas and a turbulent trail behind the object, yet we see none. The advantage with examining the original data is that one can explore the raw photon counts of the images and there is no evidence of a leading shock or trailing turbulence.

Scott (and Arp) also try to argue that these 'connections' must be real because of an alleged low probability of such a chance alignment with background galaxies (pages 200, 214). However, I have yet to find the calculation of this alleged low-probability. Most simple analyses I have done suggest the alignment probability is actually rather high. If the alignment probability is low, then Arp must also explain the other Hubble images where many additional galaxies appear as 'background' to the foreground object being imaged. Here's a few links to such images: NGC 1309⁶⁷, NGC 3370⁶⁸ and the Tadpole galaxy⁶⁹. The newer ACS camera aboard Hubble reveals many of these in almost every deep galaxy image.

Is Arp claiming that all of these objects are small galaxies ejected from the larger 'foreground' galaxy?

What about all the smaller galaxies that appear in the Hubble Deep Fields⁷⁰ and Hubble Ultra Deep Field⁷¹? These images were taken in a patch of sky that appears 'empty' to ground-based telescopes, yet it revealed many galaxies. Does Arp believe these 'small', high-z galaxies are ejecta from other low-z galaxies? If they are background galaxies, how can he tell?

Dr. Arp's probability argument has some serious flaws in it.

In some cases, we see a quasar through the disk of a galaxy. Arp argues that you can't see through a galactic disk (page 208). Yet studies have been done on the transparency of galactic

⁶⁶ "Runaway Star" <http://antwrp.gsfc.nasa.gov/apod/ap991127.html>

⁶⁷ "The Hubble Heritage Project: Spiral Galaxy NGC 1309". <http://heritage.stsci.edu/2006/07/index.html>

⁶⁸ "The Hubble Heritage Project: Spiral Galaxy NGC 3370". <http://heritage.stsci.edu/2003/24/index.html>

⁶⁹ "Astronomy Picture of the Day: Arp 188 and the Tadpole's Tidal Tail". <http://antwrp.gsfc.nasa.gov/apod/ap020502.html>

⁷⁰ "Astronomy Picture of the Day: The Hubble Deep Field". <http://antwrp.gsfc.nasa.gov/apod/ap980607.html>. "Astronomy Picture of the Day: The Hubble Deep Field South". <http://antwrp.gsfc.nasa.gov/apod/ap981214.html>. "STSci: The Hubble Deep Field." <http://www.stsci.edu/ftp/science/hdf/hdf.html>

⁷¹ "Astronomy Picture of the Day: The Hubble Ultra Deep Field". <http://antwrp.gsfc.nasa.gov/apod/ap040309.html>. "STSci: The Hubble Ultra Deep Field." <http://www.stsci.edu/hst/udf/index.html>

disks and concluded that galactic disks are indeed rather transparent when face-on⁷². The galactic disk would only be completely opaque if the stars, dust, and gas were so thick that every photon from the other side of the disk were stopped. We see examples of this with spiral galaxies that are seen edge-on and the dust lane in the disk is sufficiently thick to block all light, however, face-on and near face-on disks are another matter.

Yet there is another example simpler than this. WE SEE THROUGH THE DISK OF OUR OWN GALAXY! As we look through the night sky, we easily see extragalactic objects. They only experience severe extinction when we try to view them through the long dimensions of our own galactic disk, the so-called “Zone of Avoidance”, which exists near the band of the Milky Way across the night sky. But even then, we see out to over 2 kiloparsecs in the disk. To an extragalactic observer, our region of the galactic disk would appear to be, at most, twice as thick optically as it appears to us (since we are approximately half-way through the disk) and appear only slightly less transparent than it appears to us. In many directions *in* our galactic disk, we see several thousand parsecs before obscuration by gas and dust becomes a significant problem. Even then, the gas and dust is very close to the galactic plane. Except for regions with high concentrations of dust, galactic disks are largely transparent!

The problem set at the end of this paper has a simple exercise where, using Dr. Scott’s numbers, you can demonstrate for yourself just how little light is blocked by the stars. If you wish to claim that no light from beyond can make it through a galactic disk, you are saying that the optical depth, τ , is greater than one. For this to be true for light penetrating the full thickness of the disk, it must block a considerable amount of light just penetrating half-way through the disk, which would block the visibility of stars in the disk as well. While there are local increases in dust that can significantly block the light beyond, in general, face-on and near face-on galactic disks are very transparent.

Does Dark Matter Matter?

While press reports focus on exotic possibilities for Dark Matter, cosmic strings, axions, etc., the simple answer of what Dark Matter is is simply matter below our ability to directly detect it.

White dwarf stars were an early version of dark matter, detected by their gravitational effects on Sirius and Procyon before they were directly seen in telescopes. A number of extrasolar planets were detected by similar mechanisms and make up part of the budget of Dark Matter. Even ionized hydrogen, since it has no spectral lines to be seen, can be a component of Dark Matter. Many other objects make up this budget of Dark Matter, some of which are becoming detectable with newer, more sensitive, instruments: Kuiper belt objects (KBOs), Massive Astrophysical Compact Halo Objects (MACHOs), brown dwarfs, and isolated (roaming) planets. Many of these objects are believed to be the ‘leftovers’ from the star and planet formation processes. It is

⁷² “Astronomy Picture of the Day: Seeing Through Galaxies”. <http://antwrp.gsfc.nasa.gov/apod/ap971205.html>. “ASTRONOMERS SEE GALAXIES THROUGH THICK AND THIN”. 1996. <http://www.astr.ua.edu/white/pairs/press.html>

the exotic, unexpected possibilities for Dark Matter that receives most of the press coverage. We examine the real density of Dark Matter in an exercise at the end of this paper.

Galaxies

The global cosmological model of the PC/EU advocates seems to be a universe criss-crossed by huge currents that light up galaxies (and the stars in them) as they intersect with matter. I've found nothing in their materials that indicate what maintains the potential differences that drive these currents. All the charged particles moving in these currents would gradually lose energy through radiation or collisions with the ambient medium, not to mention the energy required to light up the stars. The currents would then cease to exist.

If galaxies are formed by the intersection of giant cosmic-scale electric currents, there are a number of testable predictions from such a hypothesis. There are several possible sources of emission from these configuration.

- Currents generate their own magnetic fields and with electrons moving in them, will also generate synchrotron radiation.
- These currents are subject to the same stability problems created by their self-generated magnetic fields, as mentioned in the section on the Electric Sun.
- Electrons moving in this current will also interact with the background photon emission via Compton scattering. This is effect is already used to identify plasma clouds around clusters of galaxies (Sunyaev-Zeldovich effect) and is used to remove the foreground galaxy effects from the Cosmic Microwave Background maps of COBE and WMAP.
- The electrons in this current will interact with ambient intergalactic matter. For a given current and IGM density, what is the mean-free-path for collisions with ambient protons? What bremsstrahlung emission can be expected from these interactions? While the density is low, the distance for accumulation along the line of sight (the column depth) can be significant to produce a detectable flux.
- What flux will each of these types of radiation produce in a given energy band? How bright will these emissions be for the Milky Way galaxy? The Andromeda galaxy? Galaxies in the Virgo cluster?
- If galaxies are aligned along these current filaments, shouldn't we be able to map the currents across the sky with the aid of the cosmic background and spiral galaxy alignments?
- If stars and galaxies are just 'inert' matter, lit up by the passage of these currents, then how long do stars and galaxies last as the currents jump from one collection of matter to another?

If these cosmic scale currents are responsible for the formation of galaxies, we should see galaxies strung along them like beads. Peratt's model of spiral galaxies created at the intersection of current streams suggests that the spin axis of the galaxy should point roughly

along the direction of the current and provide additional constraints on the current streams. What about nearby spiral galaxies that are face-on to us, such as nearby M33? This model would suggest that the current is heading directly at us. What kind of interaction can we expect from these interacting streams?

Hiding in the Dark (Current)

Dr. Scott claims that all these current streams allegedly forming stars and galaxies are totally invisible, hiding behind the laboratory term “dark current” mode (also known as a Townsend current).

”Dark Current” is an optical description, limited to the perception of the experimenter. Even Scott’s own graph (Fig 13, page 102) demonstrates that the current is subject to resistance, and resistance means that energy is dissipated in some way, most likely as thermal or radio energy. At the subatomic level, this is through processes such as synchrotron radiation in the magnetic field of the current, or bremsstrahlung in scattering with the ions, and many others. While Dr. Scott mentions radio emissions from the dark current (page 73), he doesn’t seem to recognize the implications for many of his claims, that these currents have ways of being detected. More details of these implications will be discussed below.

The WMAP Map

In the WMAP image (page 186, plate 8) Scott claims that we should see shadows of the nearer galaxies superimposed on it. This map is also presented in Figure 4 below.

In the less processed maps, we do. Because clusters of galaxies have strong x-ray emission from the hot plasma around them, these ‘shadows’ alter the background emission in a very well-determined way called the Sunyaev-Zeldovich effect. By examining the emission in multiple wavelengths (wavelength bands designated as K, Ka, Q, V, and W), it is possible to map these foreground concentrations and subtract them out of the final map.

But this map also represents a problem for the PC/EU advocates as well. WHERE ARE THE CURRENT STREAMS? As mentioned in the section on galaxies, because electrons interact so strongly with photons, the current streams which create galaxies in plasma cosmology should show up as well! For nearby galaxies, and stars as well for the Electric Sun/Star model, we should see these streams and be able to construct paths back to their source. In the PC/EU model, this map should not look like a bunch of fuzzy dots, but like a bowl of spaghetti!

It’s interesting that while some studies were made of the emission properties of these extragalactic current streams⁷³, the research seems to have declined throughout the 1990s, becoming almost impossible to find after the publication of the WMAP results. I suspect WMAP did severe, possibly even fatal, damage to the hypothesis of galaxy formation by large-scale current streams.

⁷³ B. E. Meierovich and A. L. Peratt, Equilibrium of intergalactic currents, IEEE Transactions on Plasma Science, 20 (1992), pp. 891.

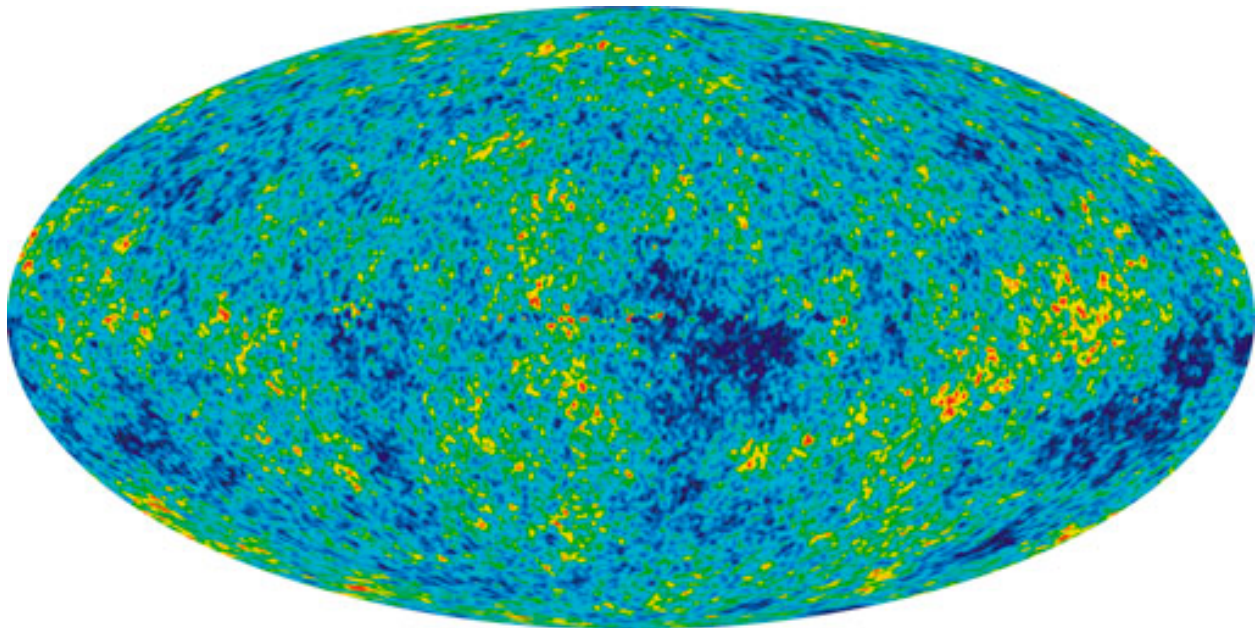


Figure 4: Processed WMAP data. This map is generated by processing all-sky maps in five different wavebands. [Credit: NASA/WMAP Science Team]

The Problem with Double Layers

One of the favorite devices used by the EU/PC advocates is the concept of double layers⁷⁴ in a plasma as a source of high-energy particles. A double layer is a region with two parallel layer with opposite electric charge, between which there is a strong electric field (Figure). Some researchers describe double layers in regions where the electric field is roughly constant and parallel to a reference surface. Invariably, their description must include the motion of electrons and ions between fixed anodes and cathodes. In a laboratory environment, the laboratory equipment performs the role of holding these electrodes fixed for the analysis (Figure 5).

What holds the electrodes fixed in free space?? If you have a region with a potential difference due to accumulation of opposite charges, it very quickly moves to eliminate the potential difference and consequently neutralizing the charges. Dr. Scott even describes this configuration as the driver of plasma oscillation frequencies described by Langmuir(pages 75-76). Yet many particle accelerator models advocated by the PC/EU community depend on the construction of these types of large charge separations, that are somehow impervious to these oscillations.

In the laboratory, there are mechanical structures that hold the electrodes apart. In space, there is generally no real structure that can perform this role and without it, the acceleration process can only operate for a very short time. This is not to say that double layers cannot form in astrophysical environments, just that the advocates need to clearly specify what maintains the

⁷⁴ Wikipedia: Double Layer (plasma). [http://en.wikipedia.org/wiki/Double_layer_\(plasma\)](http://en.wikipedia.org/wiki/Double_layer_(plasma))

structure of the anode and cathode components in their claim. While PC supporter Per Carlqvist noted the stability problems involved in maintaining double layers⁷⁵, EU and PC advocates still invoke them. These issues and more were pointed out by Bryant, Bingham and de Angelis in 1992⁷⁶.

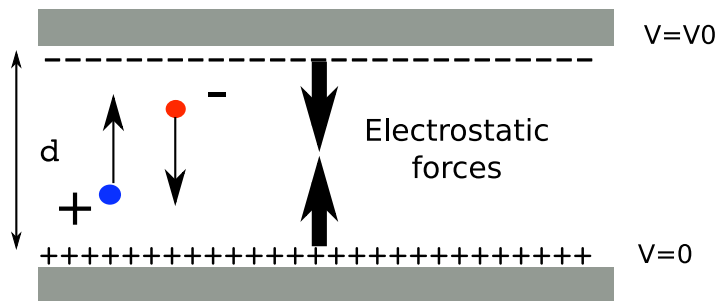


Figure 5: Double layer configuration with electrostatic forces noted.

I have encountered some references suggesting the discovery of double layers in auroral regions. However, all of these references seem to identify the double layer as the detection of a parallel electric field, not a detection of the charge separation. I have also found a number of magnetic reconnection models where induced electric fields are parallel over some regions⁷⁷.

Regions of parallel electric fields do not require charge separations like parallel-plate capacitors. They can form over limited regions with appropriate magnetic field and current configurations. This has made me wonder how much of the claims about double layers may be more of a semantics issue.

This question also illustrates a common difficulty in applying engineering principles to the natural world. It is easy to forget the effect of the infrastructure provided by the laboratory equipment. This can alter the process in radically different environments like space and weightlessness.

The Problem with Magnetic Field Lines

Dr. Scott makes repeated misrepresentations about what astronomers say about magnetic fields and magnetic field lines. Before delving into this, one should be clear just what is meant by a magnetic field line, or ‘line of force’ as it is sometimes called.

Mathematically, a magnetic field is what is called a vector field, in that at any specified point in space, the quantity has a magnitude and direction. Electric fields and fluid flows are also examples of vector fields where the direction and speed of a fluid element may vary throughout the volume under consideration. To visualize these types of systems, one has two choices:

⁷⁵ P. Carlqvist, *On the formation of double layers in plasmas.*, Cosmic Electrodynamics, 3 (1972), pp. 377–388.

⁷⁶ D. A. Bryant, R. Bingham, and U. de Angelis, “Double layers are not particle accelerators”, Physical Review Letters, 68 (1992), pp. 37–39.

⁷⁷ M. Hesse and J. Birn, *Parallel electric fields as acceleration mechanisms in three-dimensional magnetic reconnection*, Advances in Space Research, 13 (1993), pp. 249–252.

The Electric Sky, Short-Circuited

1. Draw a three-dimensional vector at every point of interest in the volume of the field or fluid to represent the quantity (Figure 6a). For any reasonably complex system, the graphics can become very quickly crowded with arrows which make interpretation difficult.
2. Construct a line or tube in three-dimensional space which represents how a fluid element or particle, starting at a given position, would travel through the volume (Figure 6b). These lines are called streamlines or field lines. For magnetic fields, this represents the guiding center path for ions and electrons.

In most cases, and particularly where the field strength covers an order of magnitude or more, option (2) creates the less-cluttered visualization and an image to which more people can relate. Almost everyone is familiar with the experiment where iron filings line up around a bar magnet.

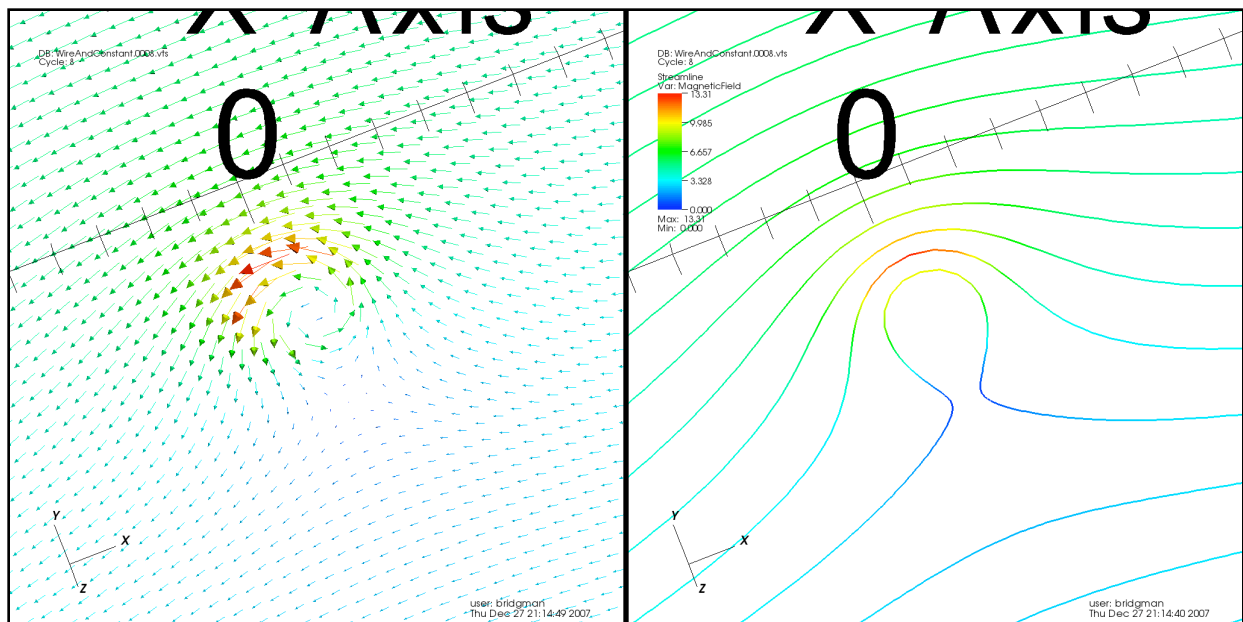


Figure 6: Examples of representing a vector field with vectors on a 2-D plane (a, left) vs. streamlines on a 2-D plane (b, right). The color represents field intensity, with red as the most intense field.

In the case of magnetic fields, they also have a useful physical interpretation. The field line is also the locus of the center of gyration for charged particles moving in a magnetic field. Charged particles at the proper energies can essentially be ‘trapped’ or ‘attached’ to the magnetic field lines and the lines provide some insight on particle flows in a plasma. However, Dr. Scott seems to have some issues with the choice of words such as ‘attach’ in this context (page 129).

Field lines are excellent representations under conditions where the magnetic field is static. The problem arises when the magnetic field changes in time. In this case, ions and electrons, which travel at a finite velocity, are subjected to a different field as they travel along the path

(instantaneously) defined by a field line. A set of field lines constructed at any given instant are only valid for a short time and over a short distance.

Magnetic field lines and flux tubes are used for visualization and conceptualization, not computation. While they are not a perfect technique, in many cases they are the best available and will continue to be used until something better is developed. Techniques such as line integral convolution and following time-varying vector fields may be improvements, but they still require hefty computational resources for visualization. Dr. Scott offers no better solution for visualizing magnetic fields in a physically insightful way, so his complaints about field lines are, at best, semantic games. Field lines are an idealization physicists use, just like electrical engineers use ideal resistors, capacitors and inductors in circuit diagrams. I have yet to find one of these components in a 'pure' form (all capacitors and inductors exhibit some resistance). Scott makes much noise about how magnetic field lines are described by some of his critics⁷⁸. However, verbal and written descriptions of these mathematical process invariably have problems. It's as bizarre as over-interpreting the use of the word "round" when discussing the shape of the Earth and arguing that the existence of mountains and valleys is evidence that the Earth is *not* round.

Even Hannes Alfvén complained about fictions of field lines, yet in many of his own plasma cosmology papers he represents physical environments with resistors, inductors, and other discrete electronic components without a clear connection back to physical quantities. He even notes his own fiction but fails to see the irony⁷⁹.

There are two other issues which Dr. Scott ignores in his complaints about magnetic fields in astronomy. One is that magnetic fields are much easier to measure than electric fields in distant locations. The Zeeman effect, polarization by scattering, and other processes driven by magnetic fields, are easier to detect than the effects produced by large electric fields. Describing theoretical models in terms of magnetic fields makes them easier to relate to actual observations. The second point is that *when astronomers talk about the behavior of magnetic fields and field lines, they usually mean their behavior in a plasma, not in free space.*

Open Field Lines: AKA, the Tyranny of Boundary Conditions

"Open" field lines is another concept that Dr. Scott condemns (page 118), but again he is only playing semantic games. In principle, magnetic and electric field lines can extend to infinity, however, in most cases we wish to examine, we don't want or need to consider the behavior at infinity. Is Dr. Scott saying that any time you want to visualize something with a magnetic field, you must represent the entire universe?

⁷⁸ D.E. Scott, "Rejoinder to Tim Thompson: Magnetic Reconnection", <http://www.electric-cosmos.org/Rejoinder.htm>

⁷⁹ H. Alfvén, *Double layers and circuits in astrophysics*, IEEE Transactions on Plasma Science, 14 (1986), pp. 779–793.

In any real analysis, we have to draw the boundary somewhere. This can leave field lines ‘cut-off’. Particles can still flow along these lines. In general, they will connect to field lines in a larger or more distant structure. In the case of magnetic dipole fields, these ‘open’ lines generally occur near the poles. If Dr. Scott claims these lines don’t exist, is he claiming that charged particles cannot travel out from these regions? Where do the charged particles go?

Fluid dynamics has a similar problem if they consider only the motion of a fluid in a limited region, but Dr. Scott doesn’t mention that.

Magnetic Reconnection

Scott makes repeated complaints about mainstream astronomy’s invocation of magnetic reconnection as a process of energy release. Yet in all of the examples he uses to dismiss the process, he examines magnetic field in air or IN FREE SPACE (pages 120-127)⁸⁰. Magnetic reconnection only becomes an energetic process when it occurs in the presence of a plasma⁸¹. Yet he repeats this error in every discussion of the subject from 2001 to 2006! This is a funny oversight by Dr. Scott, considering the entire thesis of his book is to raise the profile of the role of plasmas.

For magnetic fields in free space, there is no energetic release because there is nothing to carry the energy away. This is important because in a plasma, energy can be transferred between the charged particles and the electromagnetic field. In regions where a magnetic field changes in time and/or space, an electric field is induced which can alter the particle energy. While the field is non-zero, the ions and electrons can stay confined by the field and accumulate more energy. When the field becomes zero at the null-point (or reconnection point), the particles are no longer confined and can expand with whatever additional energy they may have accumulated during their time in the field.

We have observed the reconnection process from Earth-orbiting satellites. The Cluster satellite has observed a field configuration where a magnetic field line carrying solar particles develops a direct connection to a field line on the Earth, thereby directing solar protons to the atmosphere. This process creates a proton aurora⁸².

From there he tries to create another (flawed) analogy using gravitational fields, comparing gravitational field lines to magnetic field lines (page 124). There are two flaws in this analogy:

- 1) Gravitational field lines always begin on a massive object. This makes them more analogous to electric field lines. Mathematically, this ties back to the fact that the gravitational and electrical fields have a non-zero divergence - they start and end on field sources - masses and

⁸⁰ D.E. Scott, *Electro-Magnetic Fields and Plasma in the Cosmos*. 2006. <http://adsabs.harvard.edu/abs/2006AIPC..822..266S>

⁸¹ “Magnetic Reconnection”. http://en.wikipedia.org/wiki/Magnetic_reconnection

⁸² STORMY SPACE WEATHER SLIPS THROUGH THE CRACKS. 2003. http://www.nasa.gov/centers/goddard/news/topstory/2003/1203image_cluster.html

charges, respectively. However, the magnetic field is divergence-less since we have yet to discover magnetic monopoles.

- 2) Gravitational fields create only attractive forces. Electromagnetic fields can be attractive and repulsive.

Dr. Scott claims that gravitational fields do not undergo an ‘explosive’ release of energy (page 124). However, one should note that there is a condition where gravitational fields can ‘rapidly’ release energy. In the general gravitationally-bound 3-body problem, the three masses can interact in such a way that one of the objects is ejected from the system, leaving the other two more tightly bound gravitationally. For large, many particle systems, gravity creates the effect where over time, the central regions become more dense and compact while the outer regions become more extended due to these energy exchanges. This happens for stellar evolution, in the process of stars evolving from the Main Sequence to the Giant phase, as well as the evolution of globular clusters and elliptical galaxies. It is sometimes referred to as the ‘gravothermal catastrophe’⁸³.

Neutron Stars

At last we get to the question that originally motivated my investigation of *The Electric Sky*, Dr. Scott’s claims about neutron stars. As with most of the claims, there is Dr. Scott’s misrepresentation of the science, and the viability of the proposed alternative model.

The opening aspect of Dr. Scott’s claim is that a sphere of pure neutronium is unstable because free neutrons decay. He notes that because nuclei with a high proportion of neutrons fall above the “neutron drip line” for atomic nuclei, any large collection of nuclei will spontaneously decay. There are several errors in Dr. Scott’s analysis:

1. Neutron stars are not completely neutronium. Their outer layers are composed of heavy nuclei, free protons, and free electrons where the pressure is not high enough for neutronization to proceed.
2. Neutrons will decay *if it is energetically favorable for them to decay*. This condition is necessary, but not sufficient. This is important for distinct nuclei, as is the case with matter on the Earth.
3. Neutrons will *decay if there are empty energy states available for the decay products*. This is also a necessary, but not sufficient condition. This is important in high-density environments because neutrons, protons, and electrons are all fermions, and therefore can fit only two particles (one for each spin state) per energy level. This effect is also responsible for the atomic level structure in atoms.

The basic equation of state for degenerate neutron matter is actually very simple to analyze in the case of ignoring the electrostatic and nuclear forces, and treating each particle as a point fermion

⁸³ J. Binney & S. Tremaine. “Galactic Dynamics” Princeton University Press, 1988. pp 500-505.

in an ideal gas. In all processes of this type, in chemistry as well as nuclear physics, the equilibrium state is determined by the balance of competing reactions. In the case of our simple gas of neutrons, protons and electrons we have two reactions in competition:

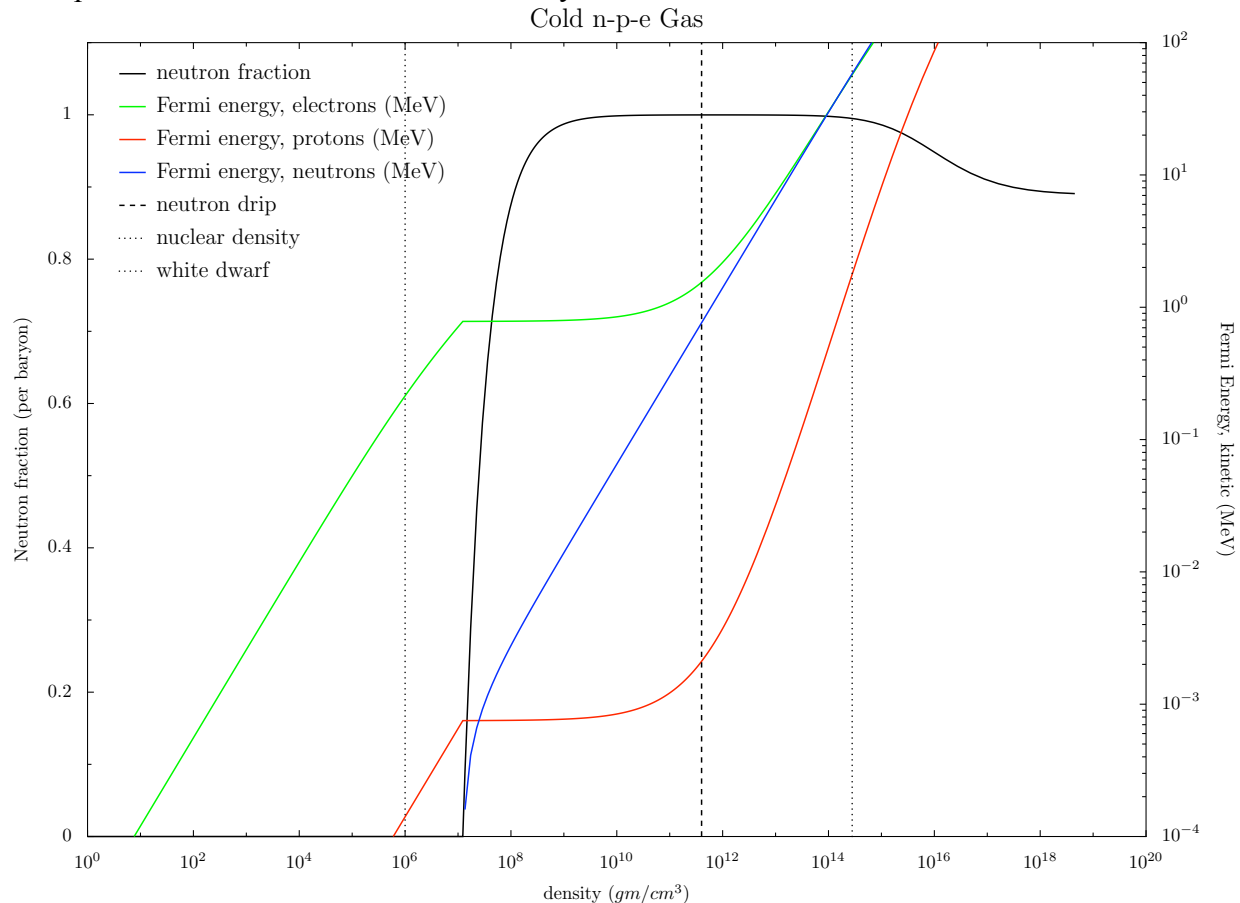


Figure 7: Neutronization vs. density in a cold neutron-proton-electron (npe) gas. Note the sharp transition in neutron fraction near 10^7 gm/cm^3 . At this point, the electrons and protons have filled their free energy states to a level where their total kinetic energy ($\sim 1.7 \text{ MeV}$) is sufficient to drive the inverse reaction and their conversion to neutrons. At this point, the neutron fraction begins to dramatically increase until the system is almost 100% neutrons.

(we will ignore the neutrinos since they will escape the system, acting as a cooling mechanism). The basics of this analysis require only algebra and are outlined in Shapiro & Teukolsky (pp 39-42)⁸⁴. From this we can compute the fractions of electrons, protons, and neutrons for a given

⁸⁴ Stuart L. Shapiro & Saul A. Teukolsky “Black Holes, White Dwarfs and Neutron Stars: The Physics of Compact Objects”. Wiley-Interscience, 1983.

density, as seen in Figure 7. Even with the approximation of non-interacting particles, the results are remarkably close to the predictions of the more detailed models.

Computing the details of neutron star structure are mathematically accessible to undergraduate physics students or even advanced high-school students, as described in “Neutron stars for undergraduates”⁸⁵. The techniques are the same used in many other areas of atomic, nuclear and particle physics, demonstrating the basics of neutron star structure rely on much of the same physics determined in Earth laboratories. It would be interesting to find out which aspects of this analysis are incorrect according to Dr. Scott.

Interestingly enough, it is in this particular topic that the physics indicates that around spinning neutron stars, non-neutral plasmas might be maintained for substantial lengths of time to drive the emission mechanisms⁸⁶.

The EU Advocates alternative pulsar model involves arcing between close binary stars. There are a multitude of problems with this model. Here are just a few.

- 1) If the stars are just bound by gravity, it is an undergraduate physics exercise to show that for millisecond timing of orbital motions, the objects must have densities similar to that of neutron stars, so the density problem still exists. See the homework problems section for the outline of this analysis to demonstrate it yourself.
- 2) If you decide to let the attractive forces be enhanced by Coulomb (electrostatic) attraction to reduce the density problem, then each discharge (pulse) would result in significant period changes as the transfer of charge changes their attractive forces. Once the charge transfer begins, how does it stop prior to both objects achieving electrical neutrality? This would result in the two bodies being held together only by gravity and killing the pulsation driving mechanism?
- 3) Astronomers have known about close binary stars (categories such as contact binaries and common-envelope binaries) for many years through spectroscopic means. The close proximity of the stars to each other keep them perpetually eclipsing each other, a characteristic easily recognized in the light curves. Isolated pulsars (those not in known binary systems) do not exhibit these characteristics.

⁸⁵ R. R. Silbar and S. Reddy, *Neutron stars for undergraduates*, American Journal of Physics, 72 (2004), pp. 892–905. This article is particularly interesting in that it relates an entertaining story about an electrical engineering student’s misunderstanding of physics at University of Massachusetts, Amherst, Dr. Scott’s former institution.

⁸⁶ F. C. Michel, *The state of pulsar theory*, (2003)

General Complaints

I've included links, and in some cases data visualizations presented above which include actual data and physics-based models. In most mainstream astronomy popularizations, the claims can be checked against dozens, or hundreds of papers on experiments, observations, and mathematical modeling which back up the interpretations. A number of researchers have made their simulation codes available for evaluation by the wider community⁸⁷. Consider Figure 1, Table 2, and Figure 7 in this work. The professional literature contained sufficient information for me to reproduce the result and obtain actual data values using well-established fundamental physics and mathematics. This is a demonstration of the *reproducibility* of the physical model - a requirement for legitimate science. Anyone with the appropriate knowledge of physics and mathematics can reproduce the work. This makes it possible to demonstrate the correctness of the model. It also makes it possible to adjust the model under different assumptions and approximations.

Where are the similar mathematical models from the EU/PC community? The only model I have seen which even comes close to professional quality is Peratt's galaxy models generated by TRISTAN and those present other problems as discussed above⁸⁸. Like most works of crank science, the Electric Universe advocates claim to explain much but seem to predict little beyond 'back-of-the-envelope' calculations, if that much. We see many claims from the Plasma cosmology advocates, but rarely have we seen the additional predictions implied by their models.

When I failed to find any actual Electric Sun model details from the ES advocates, I made several attempts to construct a physically consistent model from the resources I could find. The only model which generated any kind of reliable result was the current-to-magnetic field model presented in Table 1 which demonstrates a very large disagreement of the ES model with observations. Dr. Scott claims that the Electric Sun model does not violate Maxwell's Equations (page 115). However, I have not found an actual demonstration of this. I have attempted to model a "solar capacitor" using Maxwell's equations, but have yet to find a consistent solution in anything beyond the simplest, least realistic cases. I suspect such a solution does not exist, but I've not yet given up.

Can we get any robust numerical predictions from the EU advocates? I have yet to find any. While they try to claim that one or two percent variances in observations vs mainstream science model predictions are validations for their models, attempts to generate any predictions from their models are off by many orders of magnitude. These are not the characteristics of correct theories. It's barely a characteristic of hypotheses!

⁸⁷ Public Codes for Nuclear Astrophysics, <http://www.jinaweb.org/html/codes.html>. Some astronomy codes, http://cococubed.asu.edu/code_pages/codes.shtml. Astro-Sim: <http://astro-sim.org>.

⁸⁸ I managed to find the TRISTAN code online. I have successfully compiled but so far been unable to generate any kind of successful run.

The Electric Sky, Short-Circuited

Most of the graphs presented in Scott's book in support of an electrical interpretation of many phenomena lack clear numerical predictions. Consider Figure 10 (page 90), a graph which lacks values for voltages and altitudes above the solar surface. Numerical values could be used to generate additional predictions (such as detailed ion motions) that could be compared to other observations (Doppler shifts of those ions). As it is, the graph appears to be hand drawn and not based on any physical model. Or Figures 41 (page 153) and 45 (page 169) where the abscissa of the graph represents current density at the star's surface, but it lacks numerical values which could be used to generate additional predictions and therefore observational tests. Lack of numerical values again suggests the lack of physics-based input. Many of the predictions, such as an electric stellar evolution model (page 168) are intrinsically descriptive and give little in the way of clear numerical predictions that can be compared to observations. I haven't found anything similar from the Electric Universe advocates that even comes close to fitting observational data such as the demonstration fitting Big Bang parameters on Max Tegmark's web site⁸⁹.

It's amazing how many of Scott's claims are based on surprisingly small anomalies between the model and observations. In the solar models, composition and sound speed observations differ by less than one percent of the model prediction. Interesting enough, I've found NO detailed mathematical models from the Electric Star advocates beyond their claims in prose and a handful of isolated equations. As we saw in the Electric Sun model, applying known physical principles to their model to generate additional testable predictions produces results far out of line with observation.

Such radical changes in the global properties of the Sun generate radical changes in other areas far beyond the anomalies they wish to explain. The consequences often make a far larger body of data anomalous. This is equivalent to saying "The existence of mountains is an anomaly to the theory of a round Earth. Therefore mountains are evidence that the Earth is not round." It ignores that every human statement or even mathematical model is accurate to some level of approximation.

The Universe through the Eyes of Engineers

One of the common errors made by engineers when trying to invoke their laboratory experiences with voltages and currents extrapolating to cosmic-scale phenomena is to forget the apparatus which they use to produce the phenomenon. While the light emission may be impressive, the energy release is still small compared to the strength of the mechanical equipment used to produce it.

If electrical energy reaches these levels of power, they can literally destroy the mechanical equipment as in the case recently at CERN when a superconducting magnet, mounted with a

⁸⁹ Max Tegmark's library: Concordance Cosmology. <http://space.mit.edu/home/tegmark/concordance.html>

The Electric Sky, Short-Circuited

mechanical structure built to incorrect specifications, was powered up⁹⁰⁹¹. In the laboratory, the mechanical structures are generally far stronger than the electromagnetic forces being examined.

While the point is made that electromagnetic forces (in their raw form) are 10^{39} times stronger than gravity, they fail to note that electromagnetism has attractive and repulsive forces. If you want to actually extract all that energy, you must first create large accumulations of like charges, or separate significant amounts of positive and negative charges. These processes require at least as much energy to create (because accelerating charges lose energy by radiation) as you obtain when they combine to release their energy.

Where does the energy come from to form these accumulations?

Gravity gets around the accumulation problem by virtue of the fact it is always attractive. Any additional accumulating matter can release more energy as it falls into the gravitational well.

Then there is the communication problem. Even Dr. Scott's hero, Hannes Alfvén, talks about the problems he had yet seems to not recognize their implications.

Alfvén notes that Fermi explained his model of cosmic ray acceleration "in such a clear way that no one could doubt their possible existence"⁹². As one of my undergraduate professors would say, "You might have the greatest theory in the world, but if you can't explain it in a form that others can actually USE it, your theory is irrelevant."

Alfvén recognizes that viewing things from an engineer's point of view has one serious disadvantage: "When I describe the phenomena according to this formalism, most referees do not understand what I say and turn down my papers."⁹³ Not surprising. Many PC papers use resistors, capacitors, and inductors to describe things in a space environment and provide no mapping between these parameters and the density, temperatures, and pressures which we infer from observations. Space is not made of discrete components, but rather continuous environments which vary in temperature, density, and composition. One must write one's papers with that language in mind. If you want to write the Great English Novel, don't write it in Russian!

⁹⁰ "Big Bang at the atomic lab after scientists get their maths wrong" Times Online, April 8, 2007. <http://www.timesonline.co.uk/tol/news/uk/article1626728.ece>

⁹¹ "Fermilab Statement on LHC Magnet Test Failure" March 29, 2007. <http://user.web.cern.ch/user/QuickLinks/Announcements/2007/LHCInnerTriplet.html>

⁹² H. Alfvén. *Recollection of Early Cosmic Ray Research*, 1985. <http://adsabs.harvard.edu/abs/1985ehcr.conf..427A>

⁹³ *ibid.*

Some Astrophysical Issues Dr. Scott Avoids...

Here's just a few of the discoveries in modern astronomy that Dr. Scott does not address which have serious significance for the EU/PC model...

- Observed relativistic Doppler spectral line profiles in black hole accretion disks
- Orbits of stars around the Galactic Center match the orbits of a very high mass, otherwise invisible object. This is consistent with observations in the x-ray and gamma ray spectral range suggesting a supermassive black hole in the center of the Milky Way galaxy.
- Orbital period variations for double pulsars match the predictions of general relativity.
- A strong neutrino burst was detected by the Kamiokande neutrino telescope, simultaneous with appearance of SN 1987A. This is evidence consistent with the neutronization of the stellar core in a supernova event, consistent with predictions of the standard stellar models.
- Scott makes little references to spectroscopic evidence which is the primary diagnostic method for astrophysical plasmas. Intensities of specific spectral lines tell us about temperature, composition, and ionization state of the region in question and the environment in between. Many of these datasets and methods have been subjected to extensive laboratory testing.
- The formation of 'iron peak' elements (cobalt-56, etc.) in supernovae, predicted by stellar evolution and supernovae calculations has been detected spectroscopy in supernovae, both optically, and in gamma-rays.
- Big-Bang Nucleosynthesis. Using one free parameter, the photon-to-baryon ratio, and then known physics, we obtain agreement of light-element (hydrogen, helium, lithium) abundances which differ over several orders of magnitude.

Some Demands on the EU/PC Models

There are numerous predictions possible from the EU/PC models. It seems that its supporters try to avoid them. Here's a short summary, some of which have been mentioned earlier.

- 1) Can the Electric Sun model generate far-side imagery from helioseismology data as the Standard Solar Model has achieved? Show and demonstrate your algorithms.
- 2) What is the emission of synchrotron and bremsstrahlung radiation from the current streams powering the stars and galaxies? Again, demonstrate your algorithms.
- 3) Try to solve the magnetic field anomaly described in the electric sun current model by magnetic fields induced in the body of the star. Is it possible to cancel out the large magnetic field of the current stream over the region between the Sun and Earth?
- 4) Compute the possible nuclear reaction rates that can occur in the environment of solar flares. Compute neutrino fluxes from these reactions and compare them to observed fluxes.

More like Creationism than I expected?

When I first began examining *The Electric Sky*, I considered it a diversion from my creationism debunking efforts. Now I'm not so sure. While it is not the Christian/Judaism/Islamic version of creationism, much of Scott's model hides connections behind 'invisible' dark currents. These 'Dark Currents' seem to fulfill in Scott's 'theology' the role of God in creationist claims as a form of invisible agent. If there were a large modern religion based around Thor or Zeus, their creationism would probably contain many of the concepts of the Electric Universe. *The Electric Sky* is creationism for the Norse or Greco-Roman pantheon of gods. This notion is further reinforced by the imagery used on the many web sites advocating the Electric Universe model.

Closing Comments

Astronomy is no longer just a descriptive science. This view of astronomy began dying with Isaac Newton who turned orbital mechanics into a precise science.

Saying something is explained by process 'X' because it looks like process 'X' in the laboratory tells you nothing. Until you can actually demonstrate with real calculations that have predictive power, you know nothing about the process. Theories that try to treat astronomy as a descriptive science based on back-of-the-envelope calculations and can go no further have failed already.

Mainstream cosmology is more strongly based in laboratory measurements than any of its competitors. Dark matter and dark energy are below the sensitivity of our current observational and laboratory instrument capabilities, but can be 'seen' indirectly through astronomical observations. These hypotheses also preserve the known conservation laws that appear to be related to large-scale symmetries in the Universe. Note that many of the other proposals (such as Narlikar's increasing mass, page 219) require alteration of known laboratory principles such as constancy of mass-energy, baryon number, etc.

Science by 'logical argument' is easy. It requires little effort. But such science is impotent for it generates no testable predictions with any precision. Claiming that a model says "you will measure a current at location 'x'" is nothing if your model can't tell me a range of data values I can expect. Like creationism and other crank science, the focus of the Electric Universe is on the problems in mainstream science, as a way of deflecting examination of all the larger problems in their own claims.

Simple searches on Google often directed me to resources demonstrating Dr. Scott's errors and attests to the poor quality of scholarship in this book. *The Electric Sky* is not even a good book on plasma cosmology. Many aspects seem to be made up, considering how simply I was able to track down obvious examples of his errors and construct counter-examples. Some of this stuff is so bad I wondered if the author was testing the gullibility of his readers. I had a difficult time completing this abridged analysis because of the sheer number of problems the work contained where volumes of data were available demonstrating why the Electric Universe doesn't work. I've pulled several sections from this treatment (for possible future inclusion) so I can assimilate some of the huge amounts of information I've found.

The Electric Sky, Short-Circuited

Much of the science in the book seems to be limited to pre-1900 (or a little beyond that since he does mention sub-atomic particles), but there is no mention of the results of quantum theory and little on spectroscopy and their impact on astrophysics. Scott attempts to interpret late 20th Century astronomy with 19th century science!

Many of Dr. Scott's sources are press releases. How would Dr. Scott react if someone tried to 'reinvent' electrical engineering based on their interpretation of press releases on electronics issues? For the number of claims he makes, this work is very poorly documented. In terms of misrepresentation of known science to promote 'alternative theories', I would rank it *lower* in quality to Russell Humphreys' *Starlight and Time* or Robert Gentry's *Creation's Tiny Mystery*.

Do yourself a favor. If you must buy this book, and you might if you want the entertainment value, or if you find value in understanding various human misunderstandings of science, you should also purchase a reasonable astronomy history, such as Malcolm Longair's "The Cosmic Century"⁹⁴. Longair's book is a bit more expensive and written more for graduate students or advanced undergraduates but it documents much of the observational and laboratory work that Dr. Scott practically denies even exists.

Acknowledgments; The author would like to thank Dr. Gerard Jellison for helpful comments and editing on this work.

⁹⁴ http://www.amazon.com/Cosmic-Century-History-Astrophysics-Cosmology/dp/0521474361/ref=pd_bbs_sr_1/103-2433354-7200627?ie=UTF8&s=books&qid=1193370428&sr=1-1

Appendix: The Toolbox

Here's information on some of the software that I used for generating the simulations, models, and graphics in this monograph. These tools will run on almost any modern desktop or laptop computer. They are available for Windows, Linux and Mac OS X. The models and graphics in this paper were generated on the author's personal laptop using software that is freely available to everyone.

Since astronomy depends on reproducibility, I've done this work with as many Open Source tools as possible to make it easier for others to reproduce my results and confirm that they work, or be able to clearly define where I may have made an error.

- Python: An object-oriented scripting language. <http://www.python.org>
- SciPy/NumPy: Scientific functions and numerical array handling module(s) for python. <http://www.scipy.org>
- PyX: Generates high-quality PostScript graphics using python. <http://pyx.sourceforge.net>
- VTK (Visualization Tool Kit): A graphics library for manipulating 3-D datasets. It includes routines for interfacing with Python. <http://www.vtk.org>
- VisIt: A free application for visualizing 3-D datasets. <https://wci.llnl.gov/codes/visit/>

Homework Problems

Unfortunately, most astronomy classes Americans are exposed to are descriptive classes, where the observations and interpretations are treated as a set of facts that students must memorize and regurgitate. These classes hide the details of laboratory, observational and theoretical work that went into the original interpretation and require upper-level physics training to use. Fortunately, there are a number of errors in *The Electric Sky* that are within reach of even basic physical analysis.

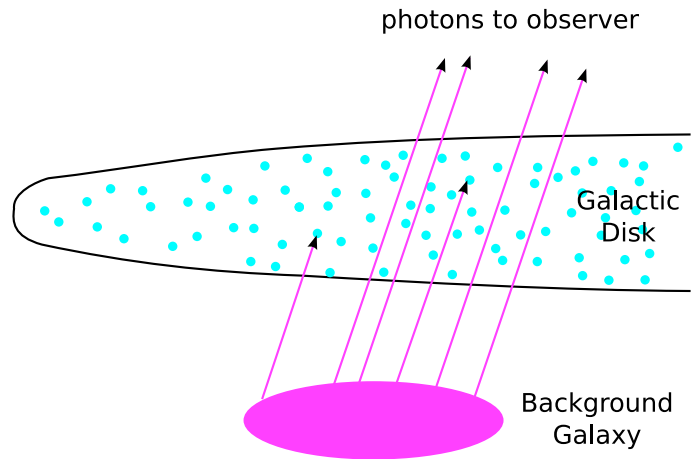
If anyone wishes to argue about the above analysis, they would raise their credibility by (correctly) doing one or more of these problems and describing its implications for the corresponding claim of the Electric Universe. If you choose to do this, like students in these fields, YOU MUST SHOW YOUR WORK!

Undergraduate Level

The embarrassing part about many of Scott's errors just how many are sufficiently simple that they can be exposed by an undergraduate physics major. I would encourage physics teachers to actually incorporate these types of exercises in their classrooms, either as in-class demonstrations of the scientific testing process or homework problems.

1. Consider simple case of a 1 metric ton (1000 kg) iron meteorite impacting at 22 km/sec. (a) What is the total kinetic energy of the impact? b) What is the equivalent explosive energy (in tons of TNT)? (c) Assume the entire kinetic energy of the object is converted into heating the object (probably a bad assumption, but an appropriate first approximation). What is the equivalent kinetic temperature of the iron atoms? (d) Recompute (c) assuming only 1% is used in heating the impacting object. What temperature? (e) Consider problem with specific heat, heat of fusion and heat of vaporization of iron included. This includes inter-atomic forces. (f) Should we be surprised that if we do/do not find evidence of the original impactor? Is it reasonable to assume these object 'plow' into a planet, or 'detonate'? Repeat calculation for velocity of 15 km/sec. Estimate the amount of energy needed to raise 1 kg of pure iron from -100C to vaporization temperature.
2. A double layer is analogous to a capacitor. Assume we have two finite planar regions a distance, d , apart with a potential difference, V , between them. Compute the force pulling these two planar regions together. Remember, in free space, they are not anchored to anything. Integrate the equation of motion of these two planar regions and compute the time it takes for them to collide and neutralize.
3. Explore the parameter space of external current power sources for the Sun. Note that these results are the minimum current needed to power the Sun for if all the current energy went into powering the Sun, the outbound current would not exist!
4. One of Dr. Scott's (and Halton Arp's?) justifications for the claim that quasar-galaxy associations have to be real is that we see the quasar against the disk of the galaxy. They claim that the quasar must be nearer because you can't see through a galactic disk (page 208).

Here we test that statement. Just how much light from a more distant object can be blocked by the disk of a foreground spiral galaxy? What fraction of light from the background galaxy makes it through the disk? Equivalently, what fraction of light from the background galaxy DOES NOT make it through the disk? Assume the disk is 1000pc thick with a stellar density of 50 stars/pc³ and each star has a radius of twice that of the Sun. Only photons which strike a stellar surface will be stopped in passing through the disk. We will ignore extinction by dust in this analysis.



5. Consider the problem above, this time including extinction by dust. If our own galaxy had an optically-thick disk, derive the apparent magnitude-galactic latitude curve. This represents how we would see a correlation between the brightness of distant galaxies (or even nearby globular clusters) with galactic latitude.
6. If the non-baryonic Dark Matter were composed of particles with the mass of protons or electrons, what number density of these particles (assuming uniform distribution) is required to account for the amount of dark matter in the concordance cosmology. How detectable is this particle density? Consider the difference in the Earth's gravitational field if one included the gravitational attraction from this dark matter, Use table from the Legacy Archive for Microwave Background Data Analysis (LAMBDA)⁹⁵.
7. Binary-powered pulsars. Perform a simple estimate of the density of a pair of binary stars to have an orbital period of one millisecond. For simplicity, assume two identical stars orbiting a common center of gravity. Recast the equations in terms of the orbital period, the mass density of the stars, and the ratio of the radius of the star to the semi-major axis of the orbit, R/a , which is always less than one half (since the stars must not be touching each other to be distinct objects). Solve for the mass density in terms of orbital period.

⁹⁵ C. L. Bennett et al., "Best" Cosmological Parameters: Table 3 from Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Results. http://lambda.gsfc.nasa.gov/product/map/pub_papers/firstyear/basic/wmap_params_table.pdf