Lessons from the Sun

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In this brief note, the implications of a condensed Sun will be examined. A celestial body composed of liquid metallic hydrogen brings great promise to astronomy, relative to understanding thermal emission and solar structure. At the same time, as an incompressible liquid, a condensed Sun calls into question virtually everything which is currently believed with respect to the evolution and nature of the stars. Should the Sun be condensed, then neutron stars and white dwarfs will fail to reach the enormous densities they are currently believed to possess. Much of cosmology also falls into question, as the incompressibility of matter curtails any thought that a primordial atom once existed. Aging stars can no longer collapse and black holes will know no formative mechanism. A condensed Sun also hints that great strides must still be made in understanding the nature of liquids. The Sun has revealed that liquids possess a much greater potential for lattice order than previously believed. In addition, lessons may be gained with regards to the synthesis of liquid metallic hydrogen and the use of condensed matter as the basis for initiating fusion on Earth.

"*Young people, especially young women, often ask me for advice. Here it is, valeat quantum. Do not undertake a scientific career in quest of fame or money. There are easier and better ways to reach them. Undertake it only if nothing else will satisfy you; for nothing else is probably what you will receive. Your reward will be the widening of the horizon as you climb. And if you achieve that reward you will ask no other.*"

Cecilia Payne-Gaposchkin [1]

When Cecilia Payne [1] discovered that the stars are primarily composed of hydrogen [2], she encountered strong opposition from Arthur Eddington, her first mentor, and from Henry Norris Russell [3]. Nonetheless, Cecilia Payne's work engendered a new age in astronomy: hydrogen became the building block of the universe. Russell would eventually come to echo Payne's position [4]. In those days, it was natural to assume that a hydrogen-based Sun would be gaseous [5, 6]. Ten years after Payne published her classic report, Wigner and Huntington proposed that condensed metallic hydrogen could be synthesized [7]. In so doing, they unknowingly provided James Jeans with the material he had lacked in constructing liquid stars [5]. Still, though liquid metallic hydrogen became a component of the giant planets and the white dwarf [8], the concept of condensed matter was kept well removed from the Sun.

Now that liquid metallic hydrogen has been advanced as a solar building block (see [8] and citations therein), it is likely that opposition will be raised, for many will foresee unsettling changes in astronomy. A liquid Sun brings into question our understanding of nearly every facet of this science: from stellar structure and evolution [9], the existence of black holes [10], the premordial atom [11], dark energy [12], and dark matter [13]. It is not easy to abandon familiar ideas and begin anew.

However, some scientists will realize that a liquid metallic hydrogen model of the Sun [8], not only opens new avenues, but it also unifies much of human knowledge into a cohesive and elegant framework. A liquid metallic Sun invites astronomy to revisit the days of Kirchhoff [14] and Stewart [15], and to recall the powerful lessons learned from studying the thermal emission of materials [16,17]. It emphasizes that our telescopes observe structural realities and not illusions [18, 19]. In recognizing the full character of these structures, all of the great solar astronomers from Galileo [20], to Secchi [21], to Hale [22] are honored. These observers knew that solar structures (granules, sunspots, pores, flares, prominences, etc...) were manifesting something profound about nature.

For astrophysicists, the Sun imparts lessons which may well have direct applications for mankind. For instance, the solar body holds the key to fusion. If the Sun is made from condensed matter [8], then our experiments should focus on this state. Sunspots may also guard the secret to synthesizing metallic hydrogen on Earth [8]. If sunspots are truly metallic [18], as reflected by their magnetic fields [22], then attempts to form liquid metallic hydrogen on Earth [8] might benefit from the presence of magnetic fields. Our analysis of the photospheric constitution and the continuous thermal spectrum should be trying to tell us something about liquids and their long range order. It is currently believed that liquids possess only short term order [23]. In this regard, perhaps physics has lacked caution in bombarding the fragile liquid lattice with X-rays and neutrons [24, 25]. These methods may fail to properly sample the underlying structure. Gentler approaches may reveal structure where none was previously believed to exist. The solar spectrum implies long range order, much like that observed in graphite [16, 17, 26]. As such, liquid metallic hydrogen on the photosphere could provide the framework for long range order, despite the fact that its only binding force lies in the need to maintain electronic conduction bands (see [8] and references therein). Most importantly, however, the Sun might be trying to tell us that we still do not properly understand thermal emission [16, 17, 27]. If gaseous models exist to this day, it is because the mechanism which produces the blackbody spectrum in graphite continues to be elusive [16, 17, 27]. Of all spectroscopic signatures, blackbody radiation remains the only one which has not been explained fully. These problems constitute serious and important questions for humanity. Unlocking these mysteries is certain to keep scientists occupied, as we continue to ponder upon the lessons discerned from the Sun.

Dedication

This work is dedicated to the memory of Miss Beckly [28, p.134], Annie Scott Dill Russell [28, p.144–146], Margaret Huggins [29], Henrietta Swan Leavitt [30, 31], Annie Jump Cannon [32–34], Antonia Maury [35], Williamina Paton Stevens Fleming [36–38], Cecilia Payne-Gaposchkin [1] and the forgotten women of astronomy [39, 40].

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References

1. Gingerich O. Obituary — Payne-Gaposchkin Cecilia. *Quart. J. Roy. Astron. Soc.*, 1982, v.23, 450–451.
2. Payne C.H. The relative abundances of the elements. *Stellar Atmospheres*. Harvard Observatory Monograph no. 1, Harvard University Press, Cambridge, MA, 1925, Chapter 13 (reprinted in Lang K.R. and Gingerich O. A source book in astronomy and astrophysics, 1900–1975, Harvard University Press, Cambridge, MA, 1979, p.245–248).
3. Greenstein G. The ladies of Observatory Hill: Annie Jump Cannon and Cecilia Payne-Gaposchkin. *Am. Scholar*, 1993, v.62(3), 437–446.
4. Russell H.N. On the composition of the Sun's atmosphere. *Astrophys. J.*, 1929, v.70, 11–82.
5. Robitaille P.-M. A Thermodynamic history of the solar constitution — I: The journey to a gaseous Sun. *Progr. Phys.*, 2011, v.3, 3–25 — A paper published in this Special Issue.
6. Robitaille P.-M. A Thermodynamic history of the solar constitution — II: The theory of a gaseous Sun and Jeans' failed liquid alternative. *Progr. Phys.*, 2011, v.3, 41–59 — A paper published in this Special Issue.
7. Wigner E. and Huntington H.B. On the possibility of a metallic modification of hydrogen. *J. Chem. Phys.*, 1935, v.3, 764–770.
8. Robitaille P.-M. Liquid metallic hydrogen: A building block for the liquid Sun. *Progr. Phys.*, 2011, v.3, 60–74 — A paper published in this Special Issue.
9. Kippenhahn R. and Weigert A. Stellar Structure and Evolution. Springer-Verlag, Berlin, 1994.
10. Webster B.L. and Murdin P. Cygnus X-1: A spectroscopic binary with a heavy companion? *Nature*, 1972, v.235, 37–38 (reprinted in: Lang K.R. and Gingerich O. A source book in astronomy and astrophysics, 1900–1975, Harvard University Press, Cambridge, MA, 1979, p.462–463)
11. Lemaître G. Un Univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extragalactiques. *Ann. Société Scientifique de Bruxelles*, 1927, v.47, 49–59.
12. Frieman J.A., Turner M.S. and Huterer D. Dark energy and the accelerating universe. *Ann. Rev. Astron. Astrophys.*, 2008, v.46, 385–432.
13. Bertone G., Hooper D., Silk J. Particle Dark Matter: Evidence, candidates and constraints. *Phys. Rep.*, 2005, v.405, 279–390; arXiv: hep-ph/0404175.
14. Kirchhoff G. Über das Verhältnis zwischen dem Emissionsverögen und dem Absorptionsvermögen. der Körper für Wärme und Licht. *Poggendorff's Annalen der Physik und Chemie*, 1860, v.109, 275–301 (English translation by F. Guthrie: Kirchhoff G. On the relation between the radiating and the absorbing powers of different bodies for light and heat. *Phil. Mag.*, ser. 4, 1860, v.20, 1–21).
15. Stewart B. An account of some experiments on radiant heat, involving an extension of Prévost's theory of exchanges. *Trans. Royal Soc. Edinburgh*, 1858, v.22(1), 1–20 (also found in Harper's Scientific Memoirs, edited by J. S. Ames: The Laws of Radiation and Absorption: Memoirs of Prévost, Stewart, Kirchhoff, and Kirchhoff and Bunsen, translated and edited by D. B. Brace, American Book Company, New York, 1901, 21–50).
16. Robitaille P.-M. Blackbody radiation and the carbon particle. *Progr. Phys.*, 2008, v.3, 36–55.
17. Robitaille P.-M. Kirchhoff's law of thermal emission: 150 years. *Progr. Phys.*, 2009, v.4, 3–13.
18. Robitaille P.-M. On Solar granulations, limb darkening, and sunspots: Brief insights in remembrance of Father Angelo Secchi . *Progr. Phys.*, 2011, v.3, 79–88 — A paper published in this Special Issue.
19. Robitaille P.-M. On the presence of a distinct Solar surface: A reply to Hervé Faye. *Progr. Phys.*, 2011, v.3, 75–78 — A paper published in this Special Issue.
20. Galilei G. and Scheiner C. On Sunspots. Translated by E. Reeves and A.V. Helden, University of Chicago Press, Chicago, 2010.
21. Secchi A. Le Soleil. Gauthier-Villars, Paris, 1870.
22. Hale G.E. On the probable existence of a magnetic field in Sun-spots. *Astrophys. J.*, 1908, v.28, 315–343.
23. March N.H. and Tosi M.P. Introduction to Liquid State Physics. World Scientific, River Edge, NJ, 2002.
24. Fischer H.E., Barnes A.C. and Salmon P.S. Neutron and x-ray diffraction studies of liquids and glasses. *Rep. Prog. Phys.*, 2006, v.69, 233–299.
25. Leclercq-Hugeux F., Coulet M.-V., Gaspard J.-P., Pouget S. and Zanotti J.M. Neutrons probing the structure and dynamics of liquids. *Comptes Rendus Physique*, 2007, v.8(7–8), 884–908.
26. Pierson H.O. Handbook of Carbon, Graphite, Diamond and Fullerenes. Noyes Publications, Park Ridge, NJ, 1993.
27. Robitaille P.M.L. On the validity of Kirchhoff's law of thermal emission. *IEEE Trans. Plasma Sci.*, 2003, v.31(6), 1263–1267.
28. Clark S. The Sun Kings: The Unexpected Tragedy of Richard Carrington and the Tale of How Modern Astronomy Began. Princeton University Press, Princeton, 2007.
29. Becker B.J. Dispelling the myth of the able assistant: Margaret and William Huggins at work in the Tulse Hill Observatory in *Creative Couples in the Sciences* (H.M. Pycior, N.G. Slack, and P.G. Abir-Am, eds.), 1996, Rutgers University Press, 88–111.
30. Pickering E.C. Periods of 25 Variable stars in the Small Magellanic Cloud. *Harvard College Observatory Circular*, 1912, v.173, 1–3.

31. Mitchell H.B. Henrietta Leavitt and the Cepheid variables. *The Physics Teacher*, 1976, v.14(3), 162–167.
32. Bok P.F. Annie Jump Cannon 1863–1941. *Publ. Astron. Soc. Pac.*, 1941, v.53, 168–170.
33. Merrill P. Annie Jump Cannon. *Mon. Not. Roy. Astron. Soc.*, 1942, v.102(2), 74–76.
34. Gaposchkin C.P. Annie Jump Cannon. *Science*, 1941, v.93(2419), 443–444.
35. Hoffleit D. Antonia C. Maury. *Sky & Telescope*, 1952, v.11(5), 106.
36. Cannon A.J. Williamina Paton Fleming, *Science*, 1911, v.33(861), 987–988.
37. Cannon A.J. Williamina Paton Fleming. *Astrophys. J.*, 1911, v.34, 314–317.
38. Spradley J.L. The Industrious Mrs. Fleming. *Astronomy*, 1990, v.18(7), 48–51.
39. Spradley J.L. Two centennials of star catalogs compiled by women. *Astron. Quart.*, 1990, v.7(3), 177–184.
40. Lankford J. and Slavings R.L. Gender and Science: Women in American Astronomy, 1859–1940. *Phys. Today*, 1990, 43(3), 58–65.