LETTERS TO PROGRESS IN PHYSICS

Commentary on the Radius of the Sun: Optical Illusion or Manifestation of a Real Surface?

Pierre-Marie Robitaille

Department of Radiology, The Ohio State University, 395 W. 12th Ave, Columbus, Ohio 43210, USA.
robitaille.1@osu.edu

In modern solar theory, the photospheric surface merely acts as an optical illusion. Gases cannot support the existence of such a boundary. Conversely, the liquid metallic hydrogen model supports the idea that the Sun has a distinct surface. Observational astronomy continues to report increasingly precise measures of solar radius and diameter. Even the smallest temporal variations in these parameters would have profound implications relative to modeling the Sun and understanding climate fluctuations on Earth. A review of the literature convincingly demonstrates that the solar body does indeed possess a measurable radius which provides, along with previous discussions (Robitaille P.M. On the Presence of a Distinct Solar Surface: A Reply to Hervé Faye. *Progr. Phys.*, 2011, v. 3, 75–78.), the twenty-first line of evidence that the Sun is comprised of condensed-matter.

> *But however difficult it may be for present theories to account for the tenuity of the solar atmosphere immediately above the photosphere, and however readily the same fact may be accounted for by the theory of Schmidt, it is certain that the observer who has studied the structure of the Sun's surface, and particularly the aspect of the spots and other markings as they approach the limb, must feel convinced that these forms actually occur at practically the same level, that is, that the photosphere is an actual and not an optical surface. Hence it is, no doubt, that the theory is apt to be more favorably regarded by mathematicians than by observers.*
>
> James Edward Keeler, 1895 [1]

James Edward Keeler was a distinguished observational astronomer [2]. Along with George Ellery Hale, he had established *The Astrophysical Journal* in 1895 [2]. In the first volume of this journal, Keeler objected to Schmidt's model of a fully gaseous Sun whose surface merely represented an optical illusion (see [3] for a full discussion). Hale echoed Keeler's objections stating, *"As a theoretical discussion the theory is interesting and valuable, but few observers of the Sun will consider it capable of accounting for the varying phenomena encountered in their investigations"* [4]. Thus, two of the greatest observational astronomers of the nineteenth century expressed serious reservations relative to the idea that the solar surface was illusionary.

Today, much effort continues to be focused on establishing a proper value for the solar radius ([5–12] and references therein). Such reports constitute a clear sign that observational astronomers recognize, at least in practice, the existence of a distinct solar surface. In fact, the measurement of the solar radius not only occupies amateur astronomers, as they map the transits of Mercury and Venus [11, 12], but also attracts the attention of our helioseismologists [5–10]. This is not solely because of the obvious implications for climate change [9]. For theoretical solar physicists, any variation in the dimensions of the Sun would have severe consequences with respect to the gaseous models [5–10]. The latter would be hard-pressed to account for fluctuations in radius. This helps to account for the reassurance experienced when the solar radius is perceived as constant [5–7].

Nonetheless, the solar radius has not definitively been established as fixed. Values obtained in the past thirty years range from $958''.54 \pm 0''.12$ to $960''.62 \pm 0''.02$ (see [10] for a complete table). In 1980, Irwin Shapiro argued that the solar radius had not decreased over time [13]. Currently, these issues cause little debate, though cyclical variations continue to be gently questioned (see [10–13] and references therein).

Perhaps the most interesting aspect of solar radius determinations remains the increased precision of the measurements over the years. Emilio et al. estimate the solar radius at $960''.12 \pm 0''.09$ [10]. This corresponds to 65 km for a radius of more than half a million kilometers (696,342 km) – an error of better than 1 part in 10,000. Others report errors on the order of $0''.02$ [10], a relatively tiny distance of less than 15 km – an error of only 2 parts in 100,000. This precision argues strongly for a distinct solar surface and the existence of a condensed solar body. It is inconceivable that a gaseous Sun would be able to create such a defined "optical illusion". The gaseous solar models argue for smoothly varying density changes, even in the region of the photosphere. As a result, the extreme precision of the solar radius determinations in the visible range, along with previous arguments for a distinct solar surface [3], constitute the twenty-first line of evidence that the Sun is condensed matter.

Dedication

This work is dedicated to my eldest son, Jacob.

Submitted on: January 25, 2013 / Accepted on: January 25, 2013
First published in online on: January 28, 2013

References

1. Keeler J.E. Schmidt's theory of the Sun. *Astrophys. J.*, 1895, v. 1, 178–179.
2. Campbell W.W. James Edward Keeler. *Astrophys. J.*, 1900, v. 12, no. 4, 239–253.
3. Robitaille P.M. On the Presence of a Distinct Solar Surface: A Reply to Hervé Faye. *Progr. Phys.*, 2011, v. 3, 75–78.
4. Hale G.E. Notes on Schmidt's theory of the Sun. *Astrophys. J.*, 1895, v. 2, 69–74.
5. Emilio M., Kuhn J.R., Bush R.I. and Scherrer P. On the constancy of the solar diameter. *Astrophys. J.*, 2000, v. 543, 1007–1010.
6. Kuhn J.R., Bush R.I, Emilio M. and Scherrer P.H. On the constancy of the solar diameter — II. *Astrophys. J.*, 2004, v. 613, 1241–1252.
7. Bush R.I, Emilio M., and Kuhn J.R. On the constancy of the solar diameter — III. *Astrophys. J.*, 2010, v. 716, 1381–1385.
8. Lefebvre S., Bertello L., Ulrich R.K., Boyden J.E., and Rozelot J.P. Solar Radius Measurements at Mount Wilson Observatory. *Astrophys. J.*, 2006, v. 649, 444–451.
9. Raponi A., Sigismondi C., Guhl K, Nugent R. and Tegtmeier A. The measurement of solar diameter and limb darkening function with eclipse observations. *Solar Phys.*, 2012, v. 278, 269–283.
10. Emilio M., Kuhn J.R., Bush R.I, and Scholl I.F. Measuring the solar radius from space during the 2003 and 2006 Mercury transits. *Astrophys. J.*, 2012, v. 750, 135(8 pages).
11. Xie W., Sigismondi C., Wang X. and Tanga P. Venus transit, aureole and solar diameter. In: *"Solar Astrophysical Dynamos and Magnetic Activity"*, *Proc. IAU Symp.*, No. 294, 2013.
12. Sigismondi C. Solar diameter, eclipses and transits: The importance of ground based observations. *Mem. S. A. It.*, 2013, v. 86, 100–103.
13. Shapiro I.I. Is the Sun Shrinking? *Science*, 1980, v. 208, no. 4439, 51–53.