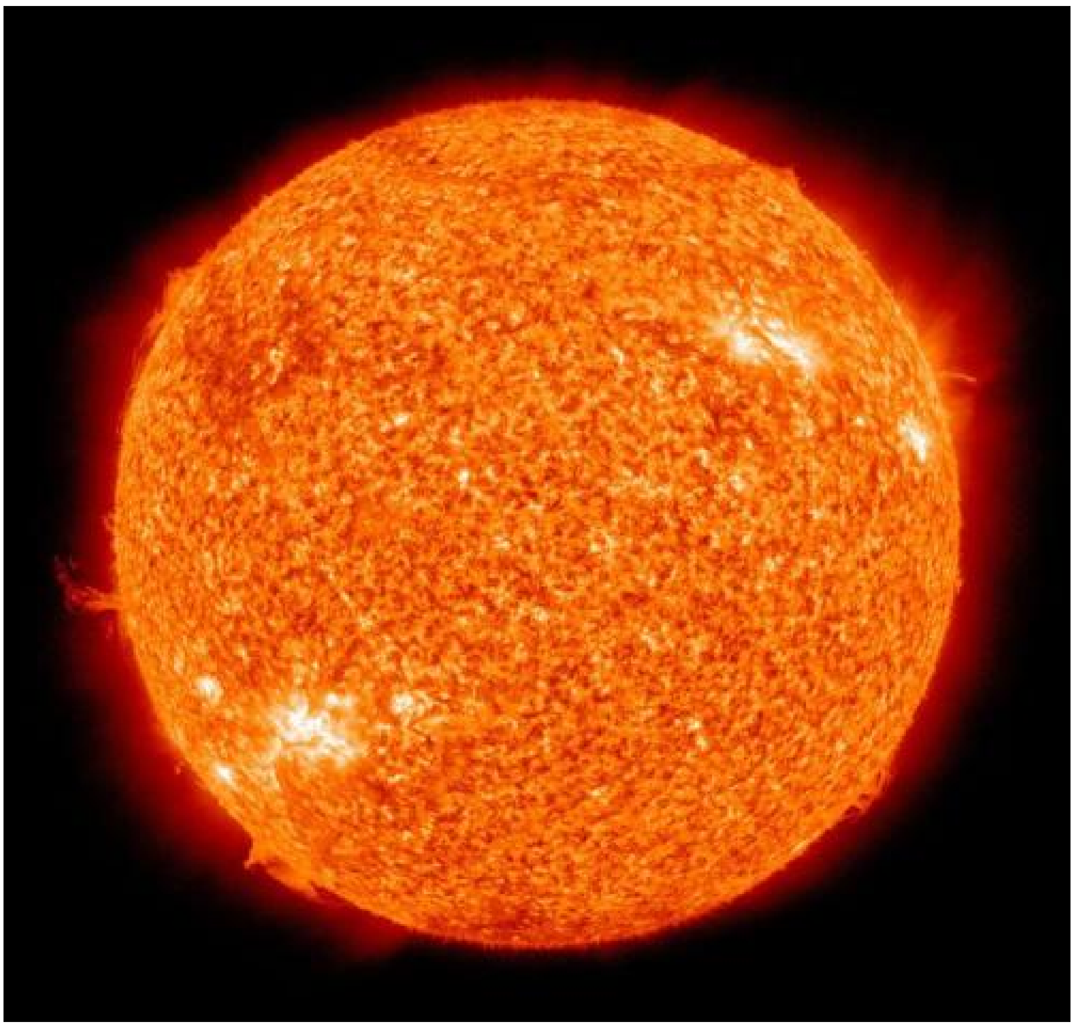
New theory to explain why sun's surface rotates slower than its core

February 6 2017, by Bob Yirka



The Sun by the Atmospheric Imaging Assembly of NASA's Solar Dynamics Observatory. Credit: NASA

(Phys.org)—A small team of researchers with the University of Hawaii, Ponta Grossa State University in Brazil and Stanford University has found what they believe is the reason that the surface of the sun rotates more slowly than its core. In their paper published in the journal *Physical Review Letters*, the team explains how they used a new technique to measure the speed of the sun's rotation at different depths and what it revealed about the speed of the sun's outer 70km deep skin.

Scientists have known for some time that the surface of the sun spins more slowly than its interior but have no good explanation for it. In this new effort, the researchers were able to take a better look at what was occurring and by doing so discovered what they believe is the source of the slowdown.

To gain a better understanding of what is happening with the sun, the researchers started with images collected by the Solar Dynamics Observatory—a probe that has been circling the sun since 2010. By processing three and a half years of images using filters, the researchers were able to get a detailed look at multiple layers of sun depth, which allowed them to calculate the circulation speed of each. In looking at their overall results, they found that the outermost layer spun more slowly than all of those below it, which spun approximately 5 percent more than the rest of the photosphere.

Taking a cue from prior research that has shown that space dust is slowed as it collides with solar photons due to losses from angular momentum, the researchers created a model of the sun in which photons moving outward through interior layers of plasma eventually encounter plasma that is much less dense at its outermost layer. As those photons collide with the plasma, which is moving, angular momentum is exchanged, which results in a net loss of plasma angular momentum. That net loss results in the plasma slowing as the photons that cause the slowdown escape into space. The massive number of such collisions over the course of 4.5 billion years, the team theorizes, has resulted in the slower rate of spin of the outer layer that we observe today.

More information: Poynting-Robertson-like Drag at the Sun's Surface, Phys. Rev. Lett. 118, 051102 – Published 3 February 2017 , doi.org/10.1103/PhysRevLett.118.051102 , On *Arxiv*: arxiv.org/abs/1612.00873

Abstract
The Sun's internal rotation {Omega}(r,{Theta}) has previously been measured using helioseismology techniques and found to be a complex function of co-latitude, {theta}, and radius, r. From helioseismology and observations of apparently "rooted" solar magnetic tracers we know that the surface rotates more slowly than much of the interior. The cause of this slow-down is not understood but it is important for understanding stellar rotation generally and any plausible theory of the solar interior. A new analysis using 5-min solar p-mode limb oscillations as a rotation "tracer" finds an even larger velocity gradient in a thin region at the top of the photosphere. This shear occurs where the solar atmosphere radiates energy and angular momentum. We suggest that the net effect of the photospheric angular momentum loss is similar to Poynting-Robertson "photon braking" on, for example, Sun-orbiting dust. The resultant photospheric torque is readily computed and, over the Sun's lifetime, is found to be comparable to the apparent angular momentum deficit in the near-surface shear layer.