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Temperatures of Jupiter's and Saturn's Upper Atmospheres: The role of the Planetary Magnetic Field

Ingo Müller-Wodarg[1], Peio Iñurrigarro[1], Luke Moore[2], Tommi Koskinen[3], and Alexander Medvedev[4]

[1]Imperial College London, Department of Physics, London, UK
[2]Center for Space Physics, Boston University, Boston, USA
[3]Lunar and Planetary Laboratory, University of Arizona, USA
[4]Max Planck Institute for Solar Systems Research, Göttingen, Germany

The primary source of heating in the upper atmospheres (thermospheres) of giant planets has been subject of long debate. The conundrum (or 'energy crisis') consists in observed thermosphere temperatures at low and mid latitudes exceeding values expected from solar heating by several hundred Kelvins (Yelle and Miller, 2004), suggesting the presence of another energy source. Several theories have been proposed to explain the high temperatures, from heating by upward propagating gravity or acoustic waves (Young et al., 1997; Matcheva et al., 1999; Schubert et al., 2003) to heating of auroral regions by magnetosphere-atmosphere coupling (Yelle and Miller, 2004; Mueller-Wodarg et al., 2019). While the latter provides sufficient energy, the problem became one of global energy redistribution. On a rapidly rotating planet, Coriolis forces act to 'trap' auroral energy in the polar regions, heating up the poles but leaving the equator cold (Smith et al., 2007; 2009; Mueller-Wodarg et al., 2019). On Saturn, the redistribution of energy from pole to equator was achieved by invoking zonal Rayleigh drag, possibly related to atmospheric waves (Mueller-Wodarg et al., 2019). Using a new General Circulation Model of Jupiter, we reproduce well the observed low and mid latitude thermosphere temperatures without the need to invoke Rayleigh drag. We identify for the first time the role played by a planet's magnetic field in affecting the global energy redistribution in thermospheres.