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Understanding the role of Alfvén waves in heating solar coronal holes through laboratory experiments

Sayak Bose[1], Troy Carter[2], Michael Hahn[3], Shreekrishna Tripathi[2], Stephen Vincena[2] and Daniel Wolf Savin[3]

[1]Princeton Plasma Physics Laboratory, [2] University of California-Los Angeles, [3]Columbia University in the city of New York

e-mail (speaker): sbose@princeton.edu

Coronal holes are regions of the Sun's atmosphere with open magnetic field lines that extend into interplanetary space. These regions are ≈ 200 times hotter than the underlying photosphere. Recent observations of damping of Alfvén waves in coronal holes suggest that a wave driven process may be responsible for the temperature rise[1,2]. The mechanism of this wave damping is unknown. We have explored the effectiveness of a longitudinal gradient in Alfvén speed in reducing the energy of propagating Alfvén waves under conditions scaled to match those in coronal holes. The experiments were conducted in the Large Plasma Device[3] located at the University of California, Los Angeles. Our results[4] show that the energy of the transmitted Alfvén wave decreases as the inhomogeneity parameter, λ/L_{A}, increases. Here, λ is the wavelength of the Alfvén wave, and L_{A} is the scale length of the Alfvén speed gradient. For gradients similar to those in coronal holes, the waves are observed to lose a factor of ≈ 5 more energy than they do when propagating through a uniform plasma without a gradient. Contrary to theoretical expectations, this reduction in the energy of the transmitted wave is not accompanied by observation of a reflected wave. Nonlinear effects causing reduction in wave energy are ruled out as the amplitude of the initial wave is too small and the wave frequency well below the ion cyclotron frequency. Decrease of Alfvén wave energy due to mode coupling is unlikely, as no other mode is present. Since the total energy must be conserved, it is possible that the reduced wave energy is being deposited in the plasma. These results pertaining to coronal holes are presented.

References

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