Discovery of Confined Pseudo-shocks as a New Energy Source for the Heating of Sun's Corona

The Sun's outer corona exists with mega-kelvin temperature, and is separated from its cool surface, namely the photosphere maintaining at 6000 degrees, by only a few hundred kilometers. An outstanding problem in solar physics and astrophysics is to figure out how and why the corona is so much hotter than its surface. Answer to this question consists of significant scientific clues about the formation of Sun's own atmosphere, heliosphere and associated magnetic fields, space-weather of various planets including Earth, etc. Moreover, it also provides the analogy of how to generate the "green-energy" in laboratory plasma systems. The answer to this problem lies in the complex magnetic field which is tightly woven within the atmosphere of the Sun. Over the last few decades, numerous space and ground-based observatories have provided a variety of explanations for the origins of solar coronal heating. Two competing physical mechanisms are generally accepted to explain the heating process. The first is known as magnetic reconnection, which is related to the dissipation of the currents. The second is the energy for heating provided by oscillating magnetic fields in the form of waves.

An international team including researches from nine countries, and lead by Abhishek Kumar Srivastava from Department of Physics, Indian Institute of Technology (BHU), India, reports on a new discovery made using the observations from Interface Region Imaging Spectrograph (IRIS), showing first ubiquitous presence of pseudo-shocks around a sunspot transferring energy into the overlying corona. They serve as substantial sources of energy and mass flux to compensate the radiative and mass losses of the localized corona. The work is published recently in Nature Astronomy (DOI: 10.1038/s41550-018-0590-1). Other team members are K. Murawski, B. Kuzma, Dariusz Wojcik from UMCS, Poland; T.V. Zaqarashvili from Space Research Institute, Graz, Austria; Marco Stangalini from INAF-OAR, Rome, Italy; Z.E. Musielak from University of Texsas, USA; J.G. Doyle from Armagh Observatory and Planaterium, N. Ireland; Pradeep Kayshap from University of South Bohemia, Czech Republic, and B.N. Dwivedi from Department of Physics, IIT (BHU).

A.K. Srivastava and B.N. Dwivedi from India add that "This discovery provides the significant clues about new dynamical plasma processes, known as pseudo-shocks, which act as an energy source for the active solar corona to compensate its radiative losses". This novel finding on the first observational discovery of confined pseudo-shocks will provide a new horizon to understanding the physics of the solar atmosphere and energetic processes using modern age upcoming solar telescopes from ground and space, like 2m Indian National Large Solar Telescope; DKIST, a 4m telescope in Hawaii; Parker's Probe; Aditya-L1, etc. This work is a new break through on understanding the energy generation, and its transport in the localized solar atmosphere, especially the highly dynamic active solar corona, which further suggests the requirement of high-resolution and sub-second observations to reveal the dynamical plasma processes at ultra small-scale.

Pseudo-shocks were first noticed in supersonic duct flows in 1958 by L. Crocco, which can be decelerated to subsonic velocities and were ascribed to a possible adjustment of the velocity distribution itself. Unlike shocks, pseudo-shocks exhibit discontinuities only in the mass density, and being firstly observed in Sun's magnetized atmosphere.

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