The heating of the solar corona and acceleration of the solar wind: Insights, theory, and modeling emerging from the ESA Solar Orbiter and the NASA Parker Solar Probe missions

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The problem is easily stated and yet has endured for longer than the space age: the surface temperature of the Sun is a mere 6,500 degrees Kelvin yet the temperature of the solar corona exceeds 1 million degrees, hot enough to create a supersonically expanding wind that fills interplanetary space. What heats the solar corona? Fifty years after the discovery of the solar wind and the beginning of the space age, this remains the most outstanding unanswered question in space physics. The launches of ESA's Solar Orbiter and NASA's Parker Solar Probe spacecraft were designed to answer this question by making in situ and remote measurements of the young solar wind plasma and magnetic fields, venturing closer to the surface of the Sun than any previous missions. Parker Solar Probe has now made multiple excursions below the Alfven surface, during encounters 8 – 14, which for the first time has allowed us to observe the properties of the sub-Alfvenic solar wind that in principle is in direct contact with the surface of the Sun. The numerous observations returned by Parker Solar Probe and Solar Orbiter have motivated considerable development in theory and modeling to explain the heating of the solar corona. An emerging consensus is that the solar corona is heated via the transport and dissipation of low-frequency magnetohydrodynamic turbulence. According to the turbulence-heating model, the dissipation of quasi-2D turbulence provides sufficient energy for heating the solar corona. Recent measurements from Parker Solar Probe and observations by the Metis instrument on the Solar Orbiter spacecraft suggest that interchange reconnection of magnetic field lines in the lower solar corona generates turbulence that

can yield sufficient energy, likely in the form of advected nonlinear magnetic structures, to heat the solar corona and thus drive the solar wind. This presentation will review relevant Parker Solar Probe and Solar Orbiter observations in the context of current solar turbulence theory and modeling to show that we may have arrived at a solution to the 50-year question of the origin of the supersonic solar wind.