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A natural wind tunnel for plasma astrophysics: learning from in-situ observations of the solar wind

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The dynamics of hot, diffuse plasmas underlie most high-energy phenomena, from the origin and propagation of cosmic rays to the heating of galaxy clusters. They are also rich in interesting physics, with the lack of frequent inter-particle collisions causing surprising and complex thermodynamical properties that depend in detail on how the system is stirred. In studying the basic properties of such plasmas, we have a resource unrivalled in most of the rest of astrophysics: exquisitely detailed measurements of fluctuations, particle distributions, and structures from inside the natural wind tunnel formed by our solar wind. In this talk, I will explore recent work on understanding turbulence in collisionless plasmas and how this can be studied from a mix of theory and in-situ spacecraft observations. The goal is both to better understand the basic physics of this interesting state of matter and to provide concrete models for still-uncertain astrophysical processes. As important examples, I will consider the electron-to-ion heating ratio in black-hole accretion flows and the propagation of cosmic rays through our galaxy.

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