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Dust in the Wind: New Instabilities Across Astrophysical Systems

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Dust is ubiquitous in astrophysics, and plays a fundamental role in the plasma physics of the interstellar medium, planet formation, chemistry, cooling, absorption/extinction, acceleration of winds via radiation pressure, and more. Recently, a new and enormous family of instabilities has been identified that are generic to any dust-gas mixture (and other multi-fluid systems). These "resonant drag instabilities" could dramatically alter our inferences about all of the above, by generating very large-amplitude (orders-of-magnitude) fluctuations in the dust-to-gas ratio on micro-scales in these settings. I'll present describe these instabilities and how they manifest, and present results of novel hybrid MHD-PIC simulations of their behavior in a wide range of environments, including proto-planetary disks, stellar winds and atmospheres, molecular clouds and HII regions, and the vicinity of AGN. I'll discuss one example where dust may strongly interact with another key component of space plasmas – cosmic rays – and could potentially resolve some severe discrepancies between standard theoretical models for cosmic ray dynamics and observations of both Solar system cosmic rays and Galactic gamma-rays.

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