Planet formation could lie in stellar storms rather than gravitational instability

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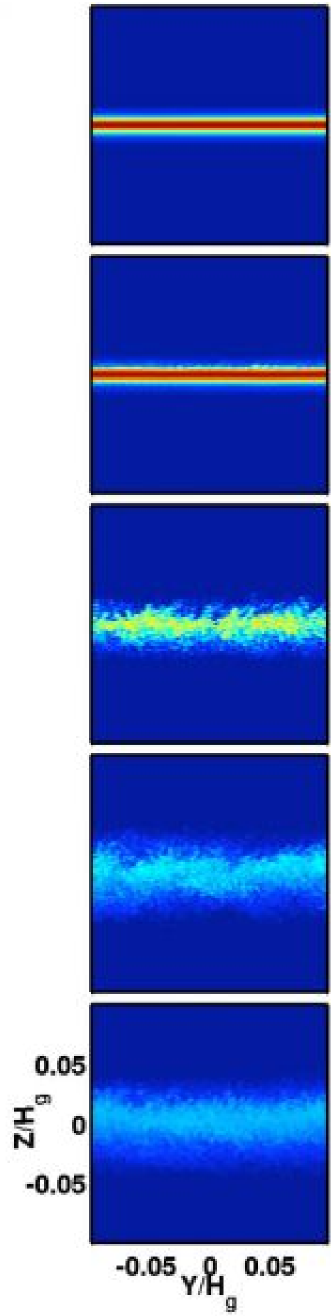
New research suggests that turbulence plays a critical role in creating ripe conditions for the birth of planets. The study, to be published in *The Astrophysical Journal*, challenges the prevailing theory of planet formation.

Using three-dimensional simulations of the dust and gas that orbits young stars, the study demonstrates that turbulence is a significant obstacle to gravitational instability, the process that scientists have used since the 1970s to explain the early stage of planet formation.



A sequence of images showing how turbulent forces (the Coriolis Effect and vertical shear) mix up the layers of dust and gas orbiting young stars. Images depict a 2-d slice through Joseph Barranco's 3-d simulations. Deep red indicates dust-rich gas. Deep blue indicates pure gas. The simulation is based on dust and gas that is the same distance away from its star as earth is from the sun. The time interval between frames is 3.4 years. Credit: Joseph Barranco

Gravitational instability proposes that dust will settle into the middle of the protoplanetary disk around a newly-formed star. It is thought that the dust will gradually become denser and thinner until it reaches a critical point and collapses into kilometer-size clumps, which later collide to form planets. But new research by San Francisco State University professor Joseph Barranco shows that turbulent forces keep the dust and gas swirling and prevent it from forming a dense and thin enough layer for gravitational instability to occur.

"These results defy the proposed solution of how planets are formed," Barranco said. "Scientists have long been using gravitational instability theory to explain how millimeter-size particles grow to kilometer-size, but these new simulations open new avenues of investigation. Perhaps massive storms, similar to hurricanes found on the Earth or Jupiter, provide clues about how tiny dust grains clump together to become kilometer-size boulders."

While previous studies have used two-dimensional models to simulate the orbiting dust and gas around young stars, these failed to take account of a crucial force that causes turbulence: the Coriolis Effect. The first to use three-dimensional models, Barranco investigated the Coriolis Effect, the same mechanism that produces cyclones and tornadoes on earth, and vertical shear. Vertical shear occurs because the faster-moving dust settles into the middle of the orbiting plane with the slower-moving gas above and below it. The velocity difference between the dust and gas causes waves to form, similar to when wind blows over the surface of water.

"What happens to the dust and gas after a period of turbulence is still an open question," Barranco said. "But it could be that in the quiet center of a hurricane-like storm, dust can collect and get trapped, seeding the beginnings of planet formation."

Source: San Francisco State University