A better understanding of space—via helicopter

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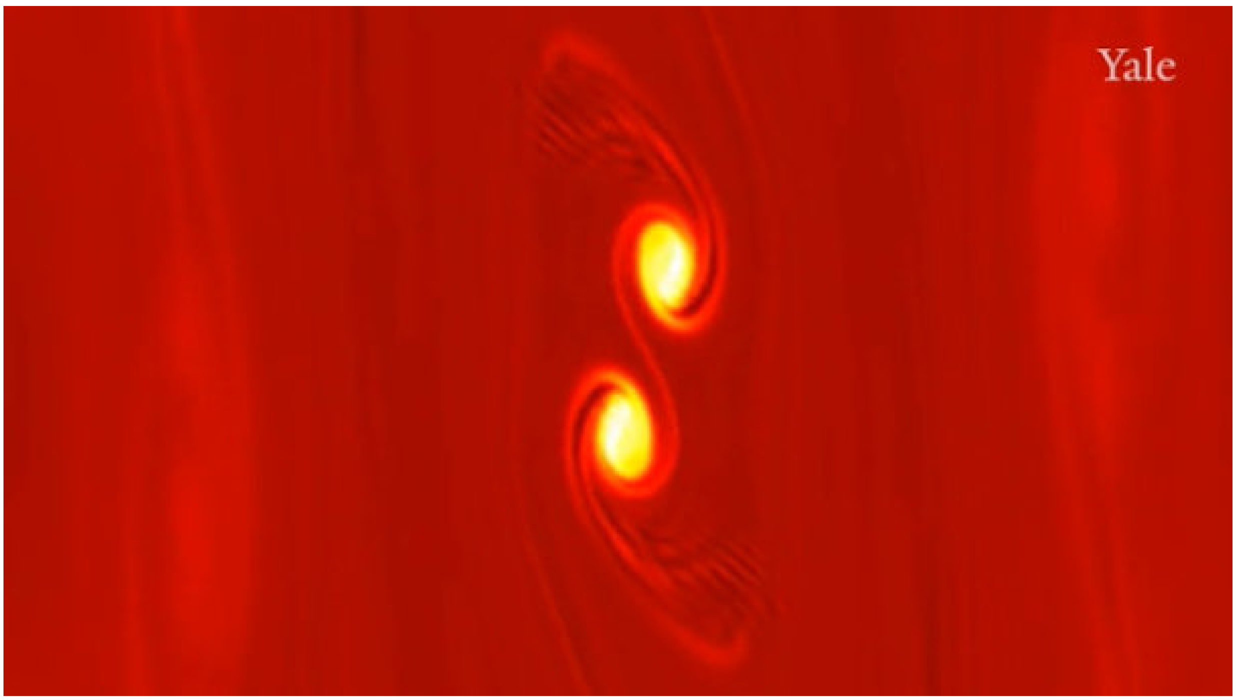

An algorithm that helps engineers design better helicopters may help astronomers more precisely envision the formation of planets and galaxies.

Yale researchers Darryl Seligman and Greg Laughlin have created a new model for understanding how black holes, planets, and galaxies emerge from the vortex-rich environments of space. They drew inspiration from a mechanical engineering algorithm that shows how air flows past a helicopter's rotor blades.

"Space is full of gas, dust, fluids, and turbulence. We wanted to do a better job of accounting for the swirling of all this material," said Seligman, a graduate student and first author of the study.

That swirling comes from a vortex—or rather, multiple vortices—which spin and pull things toward their center. In particular, Laughlin and Seligman sought to replicate the interaction of vortices in an accretion disk, which is the rotating field of matter that surrounds massive cosmic bodies such as black holes. Accretion disks are the breeding grounds for new planets, solar systems, and galaxies.

Traditional models for planet formations and similar phenomena have been based on an explosive cosmic environment, full of strong shocks. Laughlin and Seligman decided to create a new model, called Maelstrom3D, that focuses on the interplay of vortices in a less combustible cosmic environment.

Initially, the researchers looked at computer graphics simulations of explosions as a model. But they eventually decided such simulations did not contain the required level of complexity to model the turbulence of space.

That's when they came across a decade-old study by a group of mechanical engineers. The study presented an algorithm for showing how helicopter rotor blades interacted with vortices they created.

"When designing a helicopter, it's literally mission-critical to get the blade-vortex interaction right," Laughlin said. "Darryl has been able to transfer the rigorous aeronautical modeling framework to simulations of astrophysical environments, and it's clear that this makes a major difference."

Using their new model, the researchers applied it to a pair of vortices inserted into a hypothetical patch of accretion disk. They found two main differences from previous models: The vortices may be shedding Rossby waves (atmospheric waves) as they spin, and the number of orbits between the two vortices, which is related to the viscosity of the environment, is different as rendered with their model.

"We were stunned by the level of detail we were able to achieve," Seligman said.

The findings appear online in *The Astrophysical Journal*.

He added that Maelstrom3D might have other applications beyond astronomy. For example, a recent study suggested that ancient plesiosaurs generated vortices with their front flippers, which helped their back flippers generate more energy for propulsion.

"That type of fluid dynamics is very similar to the vortices generated by blade vortex interactions in a helicopter rotor or airplane wing, and is exactly the type of phenomenon our code is designed to handle," Seligman said.

More information: "A Vorticity-Preserving Hydrodynamical Scheme for Modeling Accretion Disk Flows," Darryl Seligman & Gregory Laughlin, 2017 Oct. 10, *Astrophysical Journal* iopscience.iop.org/article/10. … 847/1538-4357/aa8e45 , arxiv.org/abs/1709.07007

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