Astrophysicists uncover secret origin of brown dwarfs

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The origin of brown dwarfs is one of the great unsolved mysteries facing astrophysicists today. In a new study published in *The Astrophysical Journal*, Western's Shantanu Basu and University of Vienna's Eduard Vorobyov present a new model of brown dwarf formation that unites the best parts of existing theories and has far-reaching implications for understanding the population of low mass objects in the universe.

Brown dwarfs are astronomical objects that have too little mass to be called stars and too much mass to be called planets. Only a theoretical concept until discovered in the mid-1990s, several hundred brown dwarfs have now been identified through infrared telescopes and surveys.

"There could be significant mass in the universe that is locked up in brown dwarfs and contribute at least part of the budget for the universe's missing dark matter," said Basu, a professor in Western's Department of Physics and Astronomy. "And the common idea that the first stars in the early universe were only of very high mass may also need revision."

One leading theory suggests that brown dwarfs form like stars through the direct collapse of low mass interstellar gas cloud fragments while another speculates that they are formed after the collapse of more massive cloud fragments yield multiple bodies including brown dwarfs that are ejected due to the mutual interaction of the bodies. Both scenarios produce conceptual and theoretical problems and are equally challenged and supported by scientists.

Employing numerical hydrodynamic simulations – carried out in part by utilizing the high performance computing capabilities of Western's SHARCNET – Basu and Vorobyov show the evolution of the swirling nebular disc of gas around a newly formed protostar (or a star that is still forming) is critical to brown dwarf formation. Such a disc of gas has long been postulated to exist around the early Sun and the planets in the Solar System are thought to have condensed out of such a disc.

In the study, Basu and Vorobyov prove that the early life of a disc is characterized by the formation of multiple fragments that orbit the central protostar and that the interaction of fragments leads to the ejection of some brown dwarf fragments that have yet to fully form. The ejection speeds in this mechanism are much lower than in a model where ejections occur only for fully formed brown dwarfs and provide a more favorable comparison with observations that show that brown dwarfs are present in close proximity to young stars.

Provided by University of Western Ontario