Dirty stars make good solar system hosts (w/ Video)

October 6 2009

Some stars are lonely behemoths, with no surrounding planets or asteroids, while others sport a skirt of attendant planetary bodies. New research published this week in *The Astrophysical Journal Letters* explains why the composition of the stars often indicates whether their light shines into deep space, or whether a small fraction shines onto orbiting planets. When a star forms, collapsing from a dense cloud into a luminous ball, it and the disk of dust and gas orbiting it reflect the composition of that original cloud and the elements within it. While some clouds are poor in heavier elements, many have a wealth of these elements. These are the dirty stars that are good solar system hosts.

"When you observe stars, the ones with more heavy elements have more planets," says co-author Mordecai-Mark Mac Low, Curator of Astrophysics at the American Museum of Natural History. "In other words, what's in the disk reflects what's in the star. This is a common sense result." Observation of distant solar systems shows that exoplanets, or planets that orbit stars other than the Sun, are much more abundant around stars that have a greater abundance of elements heavier than helium, like iron and oxygen. These elements are the ones that can turn into rocks or ice.

The new simulations by Mac Low and his colleagues Anders Johansen (Leiden Observatory in the Netherlands) and Andrew Youdin (Canadian Institute of Theoretical Astrophysics at the University of Toronto) compute just how planets and other bodies form as pebbles clump into mini-planets referred to as planetesimals. Their current work hinges on their previously published research (in *Nature* in 2007) that explains why rocks orbiting a star within the more slowly-revolving gas disk are not quickly dragged into the star itself because of the headwinds they feel.

Like bicyclists drafting behind the leader in the Tour de France, the rocks draft behind each other, so that in orbits with more rocks, they feel less drag and drift towards the star more slowly. Rocks orbiting further out drift into those orbits, until there are so many that gravity can form them into mini-planets. This concentration of orbiting rocks in a gas disk is called a "streaming instability" and is the theoretical work of co-author Youdin. "It's a run-away process. When a small group of rocks distorts the flow of gas, many others rush to line up like lazy cyclists and matter accumulates very quickly," he says.

The team was able to build this mechanism—drag leading to clumping—into a three-dimensional simulation of gas and solid rocks orbiting a star. Their results show that when pebbles, made of heavy elements, constitute less than one percent of the gas mass, clumping is weak. But if the fraction of pebbles is increased slightly, the clumping increases dramatically and quickly results in the accretion of sufficient material to make larger-scale planetesimals. These mini-planets work as planetary building blocks, merging over millions of years to form planets. In short, clumping of pebbles, when the fraction of solids in the gas is high enough, is the recipe for mini-planet formation, a crucial intermediate step in forming planets.

"There is an extremely steep transition from not being able to make planets at all to easily making planets, by increasing the abundance of heavy elements just a little," says lead author Johansen. "The probability of having planets almost explodes."

Youdin adds that "There's an inherent advantage in being born rich, in terms of solid rocks. But less advantaged systems, like our own Solar

System, can still make planets if they work to marshal their resources and hang onto their solids as the gas evaporates away. So the Sun is middle-class, rather than rich." The Sun's abundance of heavy elements suggests its protoplanetary disk (the disk from which the Solar System formed) had close to the critical ratio of pebbles to gas; if the abundance of heavy elements had been slightly less, planetesimals and planets would have been far less likely to form, and we would not be here to study the question.

The results of this paper will be presented on October 8, 2009 at a meeting of the Division of Planetary Sciences of the American Astronomical Society in Puerto Rico.

Source: American Museum of Natural History

Citation: Dirty stars make good solar system hosts (w/ Video) (2009, October 6) retrieved 26 April 2024 from https://phys.org/news/2009-10-dirty-stars-good-solar-hosts.html