Model shows how gas giants could have survived and spun away from their star

April 2 2015, by Bob Yirka

This is Jupiter's Great Red Spot in 2000 as seen by NASA's Cassini orbiter. Credit: NASA/JPL/Space Science Institute

(Phys.org)—A new model developed by a team of researchers with member affiliations in Argentina, France and Mexico, depicts a possible scenario to explain why gas giants do not migrate into the star they are orbiting during their early stages. In their paper published in the journal

Nature, the researchers note that prior efforts to build a model that could explain gas giant growth and behavior did not take tidal effects into account and thus could not show why they survived. Martin Duncan of Queen's University offers a News & Views piece on the work done by the team in the same journal issue.

Gas giants, such as Jupiter and Saturn, exist today because of certain processes that went on during their early development—but until now, no one had come up with a reasonable model to explain those processes—most showed the gas giants migrating into their star during their early stages, rather than spinning away from it.

In this new model, the researchers believe tidal effects are the key. It all starts, they note, with a material disk surrounding a nearly born star. Material in that disk crashes into other material and some of it sticks—as that happens over and over more accretion takes place until the evolving planet grows large enough to start capturing gas in its atmosphere. Once that happens, the researchers say something interesting happens—as new material falls through the gas into the solid core of the planet, heat is released. That heat is then transferred back to the surrounding gas, and because the planet is spinning, parts of the gas, ahead of and behind the planet, expand—more so on the trailing side. That results, the researchers claim, in what they call a heating torque that actually pushes the still evolving planet away from its star. The model also suggests that the distance the planet is pushed from its star depends on the material that was in the original disk which made its way to the core of the new planet. Heavier elements would naturally offer more torque, but a planet's eventual resting place would also depend on the size of the planet that formed.

The model is just a first step in a new direction in trying to explain how gas giants came to be and where—research will continue both by the team with this new idea and of course by many others in the field.

More information: Planet heating prevents inward migration of planetary cores, *Nature* 520, 63–65 (02 April 2015) [DOI: 10.1038/nature14277](https://doi.org/10.1038/nature14277)

Abstract
Planetary systems are born in the disks of gas, dust and rocky fragments that surround newly formed stars. Solid content assembles into ever-larger rocky fragments that eventually become planetary embryos. These then continue their growth by accreting leftover material in the disk. Concurrently, tidal effects in the disk cause a radial drift in the embryo orbits, a process known as migration. Fast inward migration is predicted by theory for embryos smaller than three to five Earth masses. With only inward migration, these embryos can only rarely become giant planets located at Earth's distance from the Sun and beyond, in contrast with observations. Here we report that asymmetries in the temperature rise associated with accreting infalling material produce a force (which gives rise to an effect that we call 'heating torque') that counteracts inward migration. This provides a channel for the formation of giant planets and also explains the strong planet–metallicity correlation found between the incidence of giant planets and the heavy-element abundance of the host stars.