Planet-heating saves giant planet formation models

How giant planets form is a long-standing question. What we have so far known is that in the gas-dust disks around young stars the solid particles start to aggregate, collide, growing larger and larger, eventually building up planetary embryos. Previous computational simulations showed that the small embryos very rapidly migrate into the star, preventing to form planetary cores at Earth distances and beyond, at the location where giant planets form. This enduring difficulty of producing giant planets is maybe solved thanks to an international group of astronomers.

Pablo Benitez-Llambay, Frederic Masset, Gloria Koenigsberger and Judit Szulagyi, latter, from Observatoire de la Cote d'Azur found that accretional heating of the planetary embryo might solve the problem. As the embryo grows through collisions with small rocky fragments, it heats up as the gravitational energy of the accreted fragments transforms into heat. The hot embryo heats the surrounding gas as well, which then effect a force onto the embryo preventing it to migrate into the star. (see Figure 1). This way the embryo stays in the disk, and it can become massive enough to eventually form a planetary core of a giant planet.

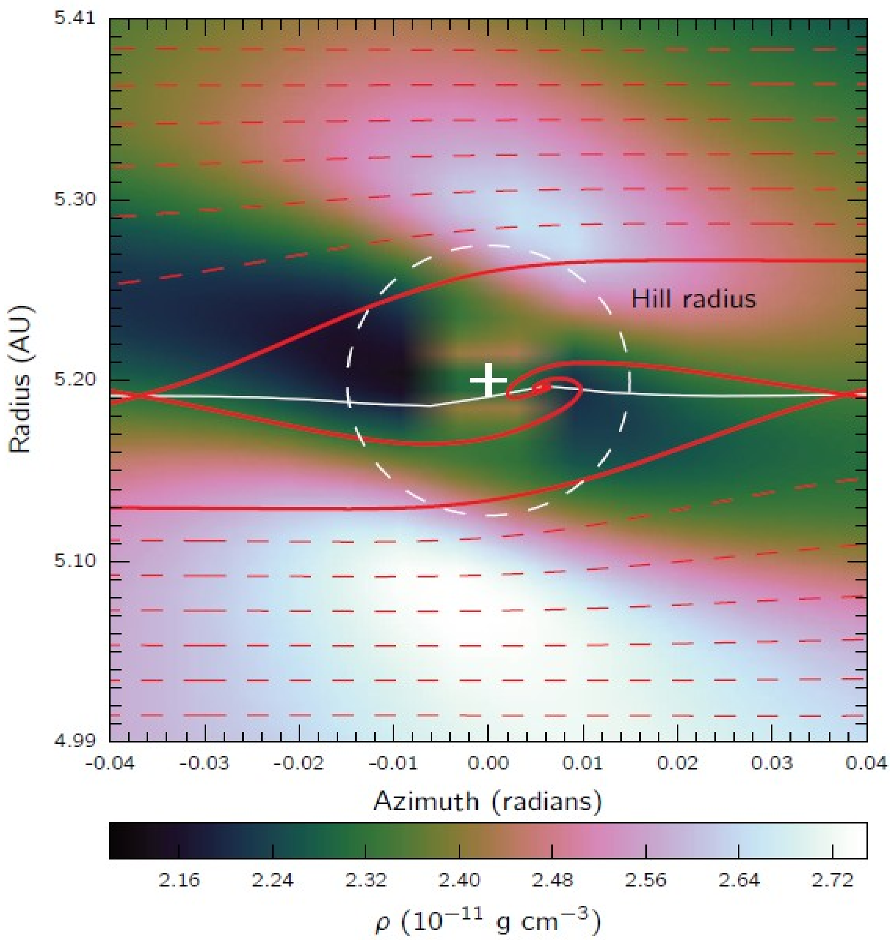

Figure 1: A density map of the gas around a 3 Earth-mass embryo (marked with a cross). Due to planet-heating, one can see two low-density regions (the dark lobes) on the left and right side of the planet. These lobes will create a force on the embryo, reversing its migration direction and pushing the embryo further away from the star. The streamlines of the gas are drawn with red.

The group performed hydrodynamic simulations of various planetary embryo masses and found that the effect counteracting the standard inward migration is the largest for 0.5 to 3 Earth-mass embryos. In addition, the heating effect scales with the accretion rate of the embryo: the more the planetary embryo is bombarded with solid debris, the more it heats up and heat the surrounding gas, which then will push the embryo further away from the star. Hence, with the higher and higher rate of the embryo's mass growth, this heat effect can either slow down the embryo's inward migration, stop it, or reverse its direction. Since the embryos are saved this way from infalling into the star, they can now grow to become planetary cores of the giant planets.

The study is published in the April 2nd edition of Nature.

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