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PLANET FORMATION IN BINARY SYSTEMS

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Summary

In this paper we discuss actual questions in the field of planet formation mechanisms. We examine tidal forces in binary systems as ome of probable mechanism for start of fragmentation. We show results from non self-gravity numerical simulations as a precondition for starting of gas fragmentation. This work is just a first step in building of a numerical model of planet formation around a star from gaseous disk as a result of tidal interaction between gas and second star.

Introduction

The understanding of the origins of our planetary system (as well as the other planets in the Universe) has always remained a question to astronomers, because of the large numbers of candidate planets and systems, founded in near past. Till the end of last year they find at least 192 planets around different kind of stars and star systems [1, 2, 3, 4]. Most of them are not alone but in planetary systems like our Solar system (not less then 155 planetary systems).

Protoplanetary disks have been observed around several young stars in our galaxy, the first being found around the star Beta Pictoris in 1984. In 1992 the Hubble Space Telescope obtained the first images of these proto-planetary disks (sometimes shortened to 'proplyds') in the Orion nebula. This is one possibility of investigation and understanding physics, origin and history of our home planet.

In our mind, it is much more realistic from one gas or dust cloud to origin a star or planetary system, but not a single star without satellites. It is because in the most of places gravitational and magnetic forces acted are not equal all everywhere in the near space. And such variations are most natural origin for star and planet burn.

So, we think that the beginning of planet formation we must search together with or such a little after the burning of the central star.

Other possible place is in yang binary and multiple star systems, where there is a free gas in a not uniform gravitational field.

Physics of Planet Formation

At the moment there are at least five theories, then are able to answer some of basic questions arising when somebody think about the origin of Solar system and other planetary systems. But there is not yet any theory confirmed all circumstances.

How one planet begins its life? Is it originate from the gas and dust between stars? Or it's life begins from star's pieces after some kind of grandiose cataclysm? And how to explain the chemical consistence of planets - why there are so many heavy elements in the Earth like planets, but not in the stars? We are well aware that hydrogen and helium are the most common elements in the Universe. Despite their abundant nature, their abundance is not so great on the inner terrestrial planets.

One explanation is *the* follows (Solar Nebula Theory):

At the initial state, the solar nebula is roughly less than 50 K (which is less than the condensation temperature of most compounds excluding hydrogen and helium). Within the solar nebula, ice coated dust grain particles are scattered and soon the gravitational attraction begin to attract all the particles toward the center of the solar nebula. As the matter is condensed, the pressure and density of the center begins to increase. This concentration of matter is referred to as the protostar (or protosun). The gravitational attraction will increase the internal temperature of the protostar and the protostar will possess an overall angular momentum. The angular momentum is significant because it maintains enough matter for planetary formation. In a sense, the solar nebula is contracted to a flattened disk with rotation.

The composition of planets themselves are dependent on their location. Near the protostar, ices will be vaporized by the high temperature and a rocky solid portion will remain. However, the ice covered dust grains are able to sustain further away from the protostar due to a decreased absorption in thermal energy.

Dust particles within the solar nebula will often coalesce into matter conglomerates referred to as planetesimals. The formation of the planetisimals is a process that requires roughly a few million years. In the case of planetisimal formation, the dust particles are held together by gravitational and electrostatic forces. Gravitational forces allowed planetisimals collided and formed larger masses called protoplanets. Inner protoplanets will accumulate material by means of accretion and this material will tend to have high condensation temperature. The impact energy and the natural decay of elements will melt the solid material and so inner planets will start their existence as spherical accumulations of molten rock. Due to a disparity in density, more dense material will sink into the center of the protoplanet. This will inevitably coerce less dense material to the surface.

Outer protoplanets are formed in a similar manner. The only main distinction is the location of the protoplanet will affect the material. The cores of protoplanets can be rocky but due to the accumulation of dust particles, the net energy would be enough to vaporize excess ices, therefore the outer planets would be composed of mainly gases.

The moons of the Jovian planets are formed in an analogous process to the planets themselves, coalescing from condensed grains in the disks which formed as the gas giant protoplanet collapsed. This explains why jovian planets all have many moons and rings in the same plane, and why jovian planets rotate quickly.

This theory explains well the nature of our planetary system. It is the most common at the moment.

But if it is the right mechanism for planet formation, the distribution of planets in other systems must be similar. During last years with accumulations of knowledge about other worlds there are found many Jovian planets very close to their stars.

There is no consensus on how to explain the observed 'hot Jupiters,' but one leading idea is that of planetary migration. This idea is that planets must be able to migrate from their initial orbit to one nearer their star, by any of several possible physical processes, such as orbital friction while the protoplanetary disk is still full of hydrogen and helium gas.

Planet formation in binary and multiple systems

We talked about the understanding of planetary system formation around a single star. But the most of the stars in the Universe are not alone. They are members of binary or multiple systems. All talks about dependence of the planets composition on their location lose their reason in this case.

From the other side, in binary and multiple systems, we have natural conditions for burning of planets. In our past works in field of accretion flow structure and dynamics [6, 7], we show that in the flow are regions with higher and lower density. If we involve the self-gravity all over the computational field, it seems realistic to see the beginning of gravitation collapse in some places.

At the beginning we plane to use our experience in numerical simulation of accretion flow in close binaries. And to try, with possible little changes to adopt it in this new field. It gives us a possibility not to make so many tests, because our code has passed enough tests yet.

At the same time, we must change star parameters from those of compact central star toward those of yang normal star and from Red giant to another yang normal star. And must include the self-gravity. But we can test first our code with self-gravity for the case of accretion flow in close binary, and then to use such a code as a first step of planet formation investigation.

This way we are not able to simulate and discuss chemical composition of planets. We plane to mace just a first little step toward building a model that can deplane full physical nature of planetary formation.

For closer to the reality simulation, we must be able to follow evolution from beginer gas and dust cloud. We must be able to take in accound chemical consistance. We must include outher gravitational and other forces that act onto the cloud. We must follow burning of stars and to see what kind of matherial remail in the space around. Only after that we can tkink about origin of planets, asteroids and so on.

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