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PLANET FORMATION – PROBLEMS AND FUTURE

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Summary

In this paper we present theories and recent investigations in the field of planet formation mechanisms. We discuss actual questions and expectations in future understanding about planet's nature. We pay attention on importance of all physical parameters and mechanisms onto the computational results in planet formation models.

The most interesting question in our mind is the origin of initial formation of more dense kernels in gas clouds as an origin for fragmentation and planetary system formation.

I. Introduction

The understanding of the origins of our planet (as well as the other planets in the Universe) has always remained a question to astronomers, but during last decades scientists all over the World looks toward the other planetary systems. Till the end of last year they find more than 160 candidate planets around different kind of stars and star systems [1, 2]. Most of them are not alone but in planetary systems like our Solar system.

Any theory for planetary system formation must answer at least on the questions about:

- formation of the terrestrial planets with solid cores.
- formation of the gaseous giant planets.
- formation of planetary satellites.
- spinning velocity of central star, planets and satellites

II. Basic theories

For about 300 years, from the middle of the seventeenth century to the middle of the twentieth, there were two fundamentally different, competing scenarios. The ***nebular hypothesis*** argued for the formation of planets from residual (or, in earlier versions, spin-ejected) circumstellar material and suggested that planetary systems may be common. The ***catastrophic hypothesis***, by contrast, regarded planets as condensates from material torn out of a star by a close encounter or collision with another star, and implied that the solar system may be exceptional.

Now there are at least five theories, satisfied some (but not all) of previous circumstances:

- **The accretion theory** assumes that the Sun passed through a dense interstellar cloud and emerged surrounded by a dusty, gaseous envelope.
- **The protoplanet theory** assumes that initially there is a dense interstellar cloud, which will eventually produce a cluster of stars. Dense regions in the cloud form and coalesce; as the small blobs have random spins the resulting stars will have a low rotation rates. The planets are smaller blobs captured by the star. The small blobs would have higher rotation than is seen in the planets but the theory accounts for this by having the 'planetary blobs' split to give a planet and satellites.
- **The capture theory** [3] assumes the Sun interacts with a nearby protostar dragging a filament of material from the protostar.
- **Modern Laplacian theory** suggested that the Sun and the planets formed in a rotating nebula, which cooled and collapsed.
- **Modern nebular theory** suggested that the planets originated in a dense disk, which formed from material in the gas and dust cloud, which collapsed to give the Sun. The density of this disk has to be sufficient to allow the formation of the planets and yet be thin enough for the residual matter to be blown away by the Sun as its energy output increased.

A consensus theory of planetary formation is now to hand based on the **nebular hypothesis**. It envisages the gradual accretion of planets, moons, and smaller objects, from cosmic dust grains and gas particles within a primarily gaseous protoplanetary disk, which is itself a byproduct of the formation of the parent star from a dense, rotating interstellar cloud.

The nebular theory of planetary system formation describes how protoplanetary disks are thought to evolve into planetary systems. Electrostatic and gravitational interactions may cause the dust and ice grains in the disk to accrete into planetesimals. This process competes against the stellar wind, which drives the gas out of the system, and accretion, which pulls material into the central star.

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.

III. Resent investigations of other Authors

Most of the authors [4 – 13] investigate the interaction between protoplanets (one, two or more) and the central star and gaseous disk around. Most of them use one of popular codes **Fargo** and **Nirvana**. Using these methods it is impossible to follow the earlier stages of fragmentation, because they don't include self-gravity.

They show excellent pictures like these below, but only after involving in the disk ring around the star some "small" bodies of several or several ten times Earth masses.

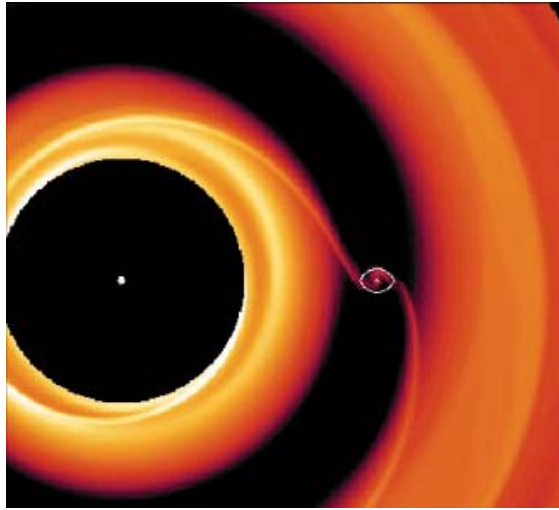


Figure 1 Protoplanets forms in the disk material circling a star, opening up a gap in the gas and dust from which it coalesces. In this model by Pawel Artymowicz of the University of Stockholm and his colleagues, the protoplanet is surrounded by a gravitational field, or Roche lobe, in which raw disk material accumulates, clumping together into a body that is recognizable as a massive planet. [3].

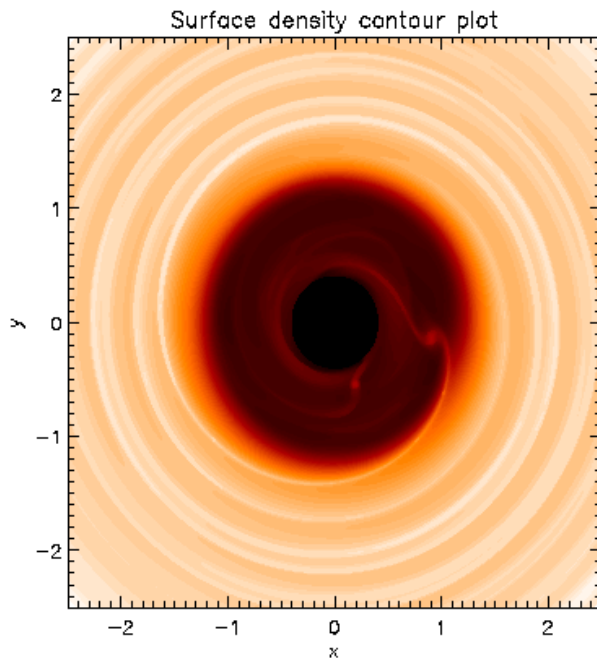


Figure 2 Here the authors [5] consider two protoplanets gravitationally interacting with each other and a protoplanetary disc. Like in the previous case, they opened a gap and formed two spiral arms.

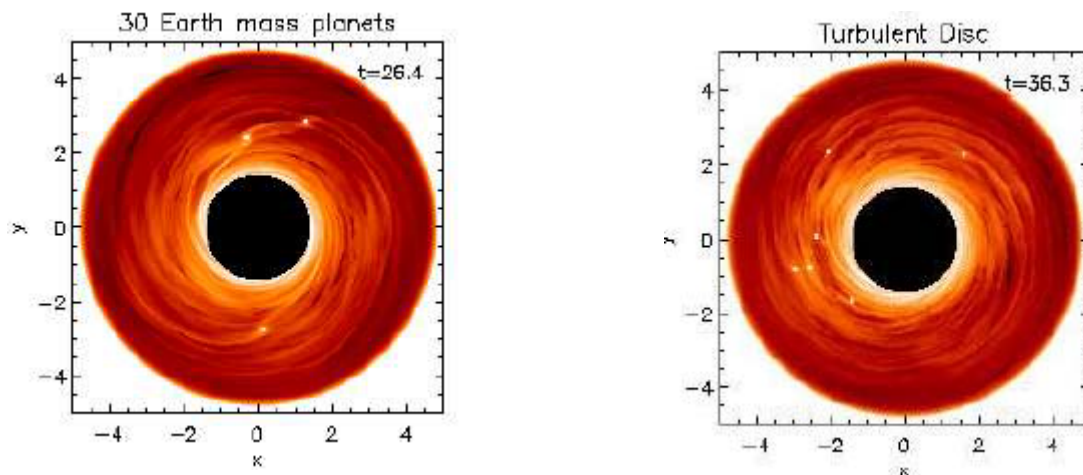


Figure 3 Here the authors [11] shows the orbital evolution of three 30 Earth mass and six 10 Earth mass planets with turbulent gaseous disk around.

IV. Our future research description

In our mind, existing investigations do not answer all of questions about origin and starting evolution of planetary systems. The most of the authors pay attention on interaction between solid bodies (planetesimals) and gas around existing stars. In many used methods self-gravity is not included in calculations. More interesting for us is the beginning of planet formation from uniform gas cloud and initialization of gravitational collapse there. Possible origins are different kinds of instabilities of hydrodynamical nature. Other one is ununiformity of gravitational field into the cloud, caused by space distribution of stars and star systems placed in the space around.

Other our interests are focused on planet formation in double and multiple star systems with gas between them, where one natural origin of gravitational collapse and solid bodies formation is gravitational field non-uniformity. For example, in our past works in field of accretion flow structure and dynamics [14, 15], we show that in the flow are regions with high and lower density. If we involve the self-gravity all over the field, it seems realistic to see the beginning of gravitation collapse in some places.

V. Physical notes

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.

It is very important to understand and follow the right physical conditions especially in beginning moments. Our first steps in future model building are to write proper equation system and to define beginning and boundary conditions.

In our works on accretion flow in close binaries, we show such a strong influence of boundary conditions on the computational results [13]. In the case of planet formation, is very important to follow evolution from the moment, possible closer to its beginning.

Because, if we don't do this, we have not possibility to define boundary and initial conditions similar to these in the nature.

It is important to follow the evolution of all planets in one platetary system together.

It is because any one of the planets change fravitational field and help or prevent growing of others. And if we start our simulation not from initios gas cloud, we need to insert realistic mass and space distribution of these planets.

In conclusion we can say that we are far from full understanding of our World. But, collecting observational data and theoretical investigation of scientists all over the world, we come closer and closer to this understanding.

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