One such possibility is characterization of the levels of maternally provided molecules that could be used as 'biomarkers' to monitor development for signs of abnormalities. If it turns out that the level of specific metabolites can be supplemented to help fetal brain development, in the way that folic acid supplements are given during pregnancy to prevent neural-tube defects, the implications for reducing neurodevelopmental disorders and promoting healthy brain development could be enormous. Much work would still need to be done before any clinical trials assessing such an approach could begin. Nevertheless, Vuong and colleagues' work provides a necessary foundation for understanding how the maternal microbiota affects normal brain development.

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Astronomy

The early onset of planet formation

Patrick Sheehan

Narrow rings and gaps have been seen in a particularly young disk of dust and gas around a nascent star, using the world's most powerful radio telescope. The finding provides a potential glimpse of the earliest stages of planet formation. **See p.228**

Young stars are typically surrounded by rotating disks of gas and dust, called protoplanetary, or protostellar, disks. These structures are, crucially, the reservoirs of material that go on to form planets, but when the planet-forming process begins is a major open question. On page 228, Segura-Cox *et al.*[1] cast light on this mystery by reporting a series of rings and gaps in a protostellar disk that is so young that its birth cloud is still collapsing to form the star and disk. Such features are frequently attributed to planets carving lanes through the disk. Given that this is perhaps the youngest disk observed to have such features, the findings help to set the timescale for the emergence of planets and place key constraints on theories of how planets assemble.

Planet formation is a complex process that involves tiny dust particles (less than one micrometre in size) accumulating until they become Earth-sized bodies, or even larger. The most popular theory that has been proposed to explain this process is core accretion[2], in which the steady accrual of small particles produces pebbles, rocks, boulders and eventually planets. One potential problem with this scenario is that planet formation can be slow, which seems to be at odds with the observation that protostellar disks older than about one million years do not seem to have enough material in them to form planets[3]. Updates to the theory have been proposed to remedy this[4,5], but, ultimately, the only way to refine models of core accretion is to determine how long it takes for planets to actually form. Naturally, the best way of doing this is to find baby planets in young disks.

One approach for detecting baby planets is to find evidence of their influence on the structure of the disk in which they are embedded. In the past five years, the Atacama Large Millimeter/submillimeter Array (ALMA) observatory in Chile has provided a wealth of high-resolution imagery of protostellar disks older than one million years. An abundance of interesting 'substructures' has indeed been found[6].

Most common are the narrow bright and dark rings that might be signs of a planet carving out gaps in the disk as it circles the star – although other features, such as spirals or large asymmetries in the distribution of material in the disk, have also been observed. One striking result is that these substructures, which might be related to planet formation, seem to exist in almost every protostellar disk that has been imaged with sufficiently high resolution to detect them[7]. The 'planets carving gaps' scenario would imply that planets can be formed in about one million years.

The frequency with which planets have been detected in disks that are more than one million years old raises questions about the earliest time at which planets, or at least disk substructures, can form. A few examples of younger disks (500,000–1,000,000 years old) with substructures have been found[8], but these are not much younger than the substructured systems that were observed before them.

Segura-Cox and colleagues' work pushes past this age limit, finding the first clear evidence of narrow bright and dark

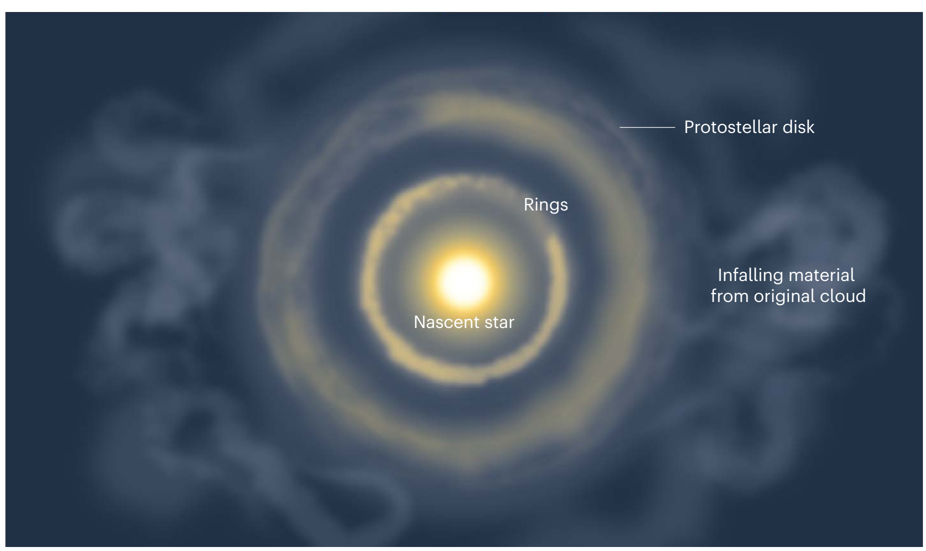

Figure 1 | Rings in a young protostellar disk. Stars form when a cloud of dust and gas collapses to produce a denser disk of material, known as a protostellar disk. The star forms at the centre of the disk, whereas planets can form from the disk material. Segura-Cox *et al.*[1] report observations of a protostellar disk that is so young (less than 500,000 years old) that the disk is still surrounded by an envelope of material from the original cloud. Rings visible in the disk could be signs of planetary formation; the rings in the actual system are very faint (see Fig. 1 of the paper[1]), but are shown more prominently here, for clarity. The findings cast light on the earliest time at which planets can form in protostellar disks.

ring-like substructures in a disk that is less than 500,000 years old. This puts new constraints on when such features can form, and on when planets can be formed (if, indeed, planets explain the presence of these features). In the ALMA image of this young disk, the authors found two dark rings accompanied by two corresponding bright rings (see Fig. 1 of the paper[1]), similar to what has been observed in older disks. Although these subtle features can be picked out from the image with a careful eye, the authors also enhanced them by subtracting a model of a smooth disk from their image, thereby sharpening the non-smooth features. In doing so, they also found evidence that the disk might be subtly asymmetric.

What is interesting is how different these features look from those found in older disks: the rings are quite shallow, and very difficult to pick out, in contrast to the prominent features found in older disks. A much larger set of observations of young disks is needed to see whether this is typical, but if it is, it could provide important clues about the planet-formation process and when it begins. Young planets might be expected to carve out large gaps, so perhaps Segura-Cox *et al.* have instead observed the build-up of dusty material into highly dense regions that would be conducive to planet formation.

Some limitations of the new study should be kept in mind. Ages of young stars are notoriously difficult to measure, and, for systems this young, we are essentially limited to using indirect methods. Stars less than about one million years old are still embedded in the cloud of material that is collapsing to form the disk and star (Fig. 1). Because this envelope of material is expected to deplete over time, the amount of material in the envelope relative to that in the disk should be a gauge of the age of the system. Measurements of these amounts, however, are difficult to make, and provide an inherently imprecise measurement of age. For that reason, it is not clear exactly how much younger the features are, compared with those of previously reported disks, and therefore how much earlier in the lifetime of a disk system this evidence of planet formation is, compared with other reported systems.

“What is interesting is how different these features look from those found in older protostellar disks.”

Moreover, although planets carving out gaps is the most exciting explanation for disk features such as those reported here, other explanations have been proposed, for example the sublimation of gases from dust grains as material travels inwards towards hotter regions in the disk[9]. This makes it difficult to ascribe these features uniquely to planets in young disks. Still, most of the potential causes of such features could contribute to the planet-formation process — and so, one way or another, Segura-Cox *et al.* are likely to have seen the beginnings of planet formation in action, in one of the youngest disks yet observed.

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