doi:10.1038/nature12405

PLANETARY SCIENCE

The robustness of planet formation

The detection of two planets in an open star cluster demonstrates that planetary systems are able to survive disruptive events, such as supernova explosions, during the dense, early stages of the life of such clusters.

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On a clear night, a person admiring the heavens may see a few thousand stars. The stars are more or less randomly distributed, although some are gathered in groups known as open clusters, the most famous being the Pleiades (Fig. 1). Stars, and presumably their planets, are born in such clusters. But despite considerable effort[1,2], evidence for planets in clusters is frustratingly scarce: of more than 850 planets that are currently known[3], only four reside in clusters[4–6]. And whereas more than 10,000 stars in open clusters have been examined, before the study by Meibom *et al.*[7] published on *Nature*'s website today, no transiting planets had been detected. Transits, which are mini-eclipses that occur when a planet passes in front of its star, are especially valuable because they allow a planet's size to be estimated. Meibom and colleagues detected two sub-Neptune-sized transiting planets in the open cluster NGC 6811, out of a sample of only 377 stars. This remarkable success rate was made possible by the ultra-precise data provided by NASA's Kepler Mission[8].

Dozens of open clusters are easily visible with a small telescope, enrapturing stargazers with the sparkling of tens to thousands of stars. The stars in a cluster are all kin, born from the same parent molecular cloud — a huge mass of cold gas and microscopic grains teetering on the brink of instability. If a cloud is nudged, it can be set down a path of cascading gravitational collapse, fragmenting into thousands of dense clumps. These condensations become smaller and smaller, heating up as they compress, until, finally, thermonuclear-fusion ignition occurs and a star is born. Leftover matter that does not form the star will continue to orbit it and may coalesce into planets.

A cluster can be far from a placid environment for planet formation. As stars pass each other, their gravity can tug on planets and planet-forming disks, and stellar winds and intense ultraviolet light from hot young stars can dissipate the star- and planet-forming cloud. The larger and denser the cluster, the more important these effects are. Although NGC 6811 is a small cluster, it is not a young one[9], and this is significant. As a cluster ages, it 'dissolves' away, its stars mixing with the myriad stars of the Milky Way; sibling stars become spread across the Galaxy. The time that it takes for the cluster to disperse, between around 10 million and 100 million years, is generally short compared with the lifetime of most stars. But about 10% of clusters persist well beyond that age, their gravity being strong enough to slow the dispersal of the stars.

To have its current number of stars, 1 billion years after its formation, NGC 6811 must have contained a much greater number of stars in the past. Conditions would have been a lot more hostile then than they are today, with numerous stellar encounters and significant evaporation of the natal cloud by hot stars. The planets and planet-forming disks may have even endured several nearby supernova explosions. The discovery of planetary systems that have withstood this challenge tells us that planet formation is robust — nature likes to create planetary systems, and many survive the birthing process.

The planets in NGC 6811 are respectively only 2.8 and 2.9 times Earth's radius. Most of the planets found by Kepler are around this size[10]. The planets' orbital periods are 18 and 16 days, also common for Kepler-discovered bodies. So these two planets seem quite typical. However, Meibom and colleagues could not measure the planets' masses because the host stars were too faint, and so the authors relied on statistical arguments to validate the planets. Using the well-established BLENDER procedure described in the paper's Supplementary Information, Meibom *et al.* estimated that the chance of a planetary transit signal being a false positive was less than 0.24%. It is probably much less than this, as the authors were quite cautious in their estimates, and rightly so, as the validation depends in part on estimating the occurrence rate of planets in clusters, and this is not independently known.

An obvious limitation of the study is that it is based on only two planets in just one cluster. However, the characteristics of the stars in NGC 6811 are similar to those of non-cluster (field) stars, and the occurrence rate of planets in the cluster and in the field were both obtained from Kepler measurements. Thus, the comparison between the two rates is straightforward, without the usual contortions

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Figure 1 | A good age. The Pleiades star cluster is roughly 100 million years old. By contrast, the open cluster NGC 6811, within which Meibom and colleagues have detected[7] two transiting planets, has survived to an age of 1 billion years.

needed to compare surveys that have different sensitivities and biases.

Most stars are thought to have formed in clusters smaller than the primeval NGC 6811, and thus probably in calmer environments. Yet Meibom and colleagues demonstrate that the planetary properties and occurrence rate in NGC 6811 are very similar to those of field stars. This implies that dense open-cluster environments do not significantly destroy planetary systems. Kepler has observed three other clusters, two of which, NGC 6819 and NGC 6791, are considerably older than NGC 6811, and presumably had even more dense and dynamically active nascent environments. NGC 6791 is especially interesting: a cluster this old, 7 billion to 9 billion years, is rare, particularly given its enrichment of elements heavier than helium. It will be truly fascinating to learn the planet occurrence rate in this cluster. ■

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