ON THE ORIGIN OF THE 3:2 ALMOST RESONANCE BETWEEN THE TWO EARTH–LIKE PLANETS ORBITING PULSAR PSR 1257 + 12. F. Marzari, V. Vanzani, *Dept. of Physics, Via Marzolo 8, 35131 Padova, Italy (marzari@pd.infn.it; vanzani@pd.infn.it)*, L. Tomasella, *Obs. of Asiago, Via dell'Osservatorio, 35012 Asiago (VI), Italy (tomasell@astras.pd.astro.it)*.

We suggest that the 3:2 almost resonance between the two more massive planets (Planets B and C) orbiting the millisecond pulsar PSR 1257 + 12 [1] might be a consequence of two independent resonances (2:1 and 3:1) with an inner low–mass stellar companion, now completely evaporated, that also generated the accretion disk from which the planets formed.

Different models have been proposed to explain the formation of Earth–like planets around the millisecond pulsar PSR 1257 + 12. One of these [2] hypothesizes that the planets formed from an accretion disk generated by an evaporative wind outflowing from a pulsar companion. A young pulsar irradiates its low–mass companion star and it drives a strong wind of stellar material out of it. This material continuously outflowing from the star can stabilize in the form of a disk around the pulsar and would extend outwards due to viscosity. In this disk the dust presumably coagulated into planetesimals that accumulated by mutual collisions into Earth–like planets. The mass loss rate from the companion would have been so strong to cause the complete evaporation of the companion, in particular if it was initially a low–mass star (between $\sim$ 0.01 to 0.1 $M_\odot$). At present we would observe only the planets which formed from the disk, leftover of the companion evaporation.

Within this scenario we found a possible explanation to the 3:2 almost resonance between the orbital periods of Planets B and C [3], the two more massive planets of the PSR 1257 + 12 system with minimum mass values of 2.8 and 3.4 $M_\oplus$, respectively. The orbit of the companion star during the evaporation process can drift outward while its mass is substantially reduced. In [4], Rasio et al. showed that the binary separation can increase of more than three orders of magnitude as a consequence of the mass outflow. In the final phase of evaporation, when the companion mass is lowered down to planet–size values, the drift may have considerably slowed down [4] and the companion may have stabilized into an orbit embedded in the inner region of the accretion disk created by the evaporation process. If the companion lasted in this stage for a timescale of the order of a few 10^4 years or more, before its final slow evaporation, its gravitational perturbation would have affected the process of planetesimal accretion undergoing in the disk. The effects of mean motion resonances can easily build up on a short timescale since the orbital periods of planetesimals in the region where the planets formed range from about 60 to 100 days.

Patterson [5] argued that capture of planetesimals in mean motion resonances with a planetary embryo in an internal orbit can accelerate accretion at the resonance location in the early stage of planetary formation. In the proposed scenario for the pulsar planet formation, the role of the planetary embryo is taken by the evaporating stellar companion, still massive enough to induce nearby resonances. The planetesimals drifting towards the inner region of the disk, as a result of gas drag, are trapped in exterior resonances with the stellar companion, now reduced to a planet–size object, and they are confined in a limited phase space set by the resonance width. The collision rate at the resonance locations is greatly increased and accretion is especially fast. In correspondence to the 2:1 and 3:1 resonance with the companion we expect to assist to the rapid formation of proto–planets and, finally, of planets. Once the companion is completely evaporated, the two planets that formed at the 2:1 and 3:1 exterior resonances with the companion are left near a mutual 3:2 resonance, that is the near–commensurability between the periods of the two planets we detect at present. The 3:1 resonance is weaker compared to the 2:1. However, Patterson in [5] showed that even second order resonances do affect the accretion process. In effect, the relative weakness of the 3:1 resonance respect to the 2:1 might be reflected in the lower mass of Planet C (2.8 $M_\oplus/sin\ i$), supposed to form in our scenario at the 3:1 resonance location, compared to Planet B (3.4 $M_\oplus/sin\ i$) supposed to form at the 2:1 resonance location.

The innermost Moon–size planet (Planet A), assuming it is not an artefact due to solar wind [6], could have formed in the regions of the disk interior to the orbit of the evaporating companion of the pulsar. This would explain its low mass and the absence of resonant ratio with the other planets.

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