SCATTERING OF PLANETESIMALS FROM THE FEEDING ZONE OF PLANET PROXIMA CENTAURI C

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Introduction: The motion of planetesimals and other bodies in the Solar System was studied in many papers (see e.g. the review in [1]). I studied the motion of planetesimals in the Proxima Centauri planetary system [2-4]. In these calculations, the gravitational influence of the star (with a mass equal to 0.122 of the solar mass) and two planets: *b* (a_b=0.04857 AU, e_b=0.11, m_b=1.17m_E, m_E is the mass of the Earth) and *c* (a_c=1.489 AU, e_c=0.04, m_c=7m_E) was taken into account. The planetesimals were excluded from integration when they collided with the star or the planets or reached 1200 AU (the Hill radius of the star) from the star. The symplectic code from [5] was used for integrations. In most calculations, the integration time step t_s equaled to 1 day. The obtained results were about the same for different considered t_s equaled to 0.2 day, or 0.5 day or 2 days. The considered time interval usually exceeded 100 Myr. For some variants it reached 1000 Myr. The late gas-less stage of formation of planets was considered. Migration of planetesimals from the feeding zone of planet *c* was calculated. In each calculation variant, initial semi-major axes a_o of orbits of 250 planetesimals were in the range from a_{min} to a_{min}+0.1 AU. In different variants, the values of a_{min} were in the range from 0.9 to 2.2 AU. Initial eccentricities e_o of orbits of planetesimals equaled to 0.02 or 0.15. Initial inclinations of orbits of the planetesimals were equal to e_o/2 rad. Not small considered eccentricities of planetesimals could be a result of the previous evolution of the disk of planetesimals.

The feeding zone of Proxima Centauri *c*: The range **(**a_{mine}, a_{maxe}) of a_o for which planetesimals were mainly ejected into hyperbolic orbits or collided with planets was about $a_{mine}=a_c(1-e_c)-e_o a_{mine}-k_{min}a_c\cdot\mu^{1/3}$ and $a_{maxe}=a_c(1+e_c)+e_o a_{maxe}+k_{max}a_c\cdot\mu^{1/3}$, where k_{min}=2.54 and k_{max}=2.40 at e_o=0.02, and k_{min}=2.23 and k_{max}=4.3 at e_o=0.15, a_c and e_c=0.04 are the semi-major axis and eccentricity of the orbit of planet *c*, μ is the ratio of the mass of planet *c* to the star mass [2]. After hundreds of millions of years (after accumulation of planet *c*), some planetesimals could still move in elliptical resonant orbits (e.g. at the resonances 1:1, 5:4, and 3:4) inside the feeding zone of planet *c* that had been mainly cleared from planetesimals. The number of such left planetesimals was greater at small eccentricities.

Motion of planetesimals to the inner planets *b* and *d*: The total mass of planetesimals ejected into hyperbolic orbits was estimated to be about (3.5-7)m_E [3]. The total mass of planetesimals in the feeding zone of planet *c* could exceed 10m_E and 15m_E at e_o=0.2 and e_o=0.15, respectively. Based on the amount of planetesimals ejected into hyperbolic orbits, it was concluded [3] that the semi-major axis of the orbit of planet *c* could decrease by a factor not less than 1.5 during accumulation of this planet. Planet *d* was not included in integrations, but the probability of collisions of planetesimals with planet *d* was calculated based on the arrays of orbital elements of migrated planetesimals. The probability of a collision of a planetesimal initially located in the feeding zone of planet *c* with planet *b* was about $2\cdot10^{-4}$ and 10^{-3} at e_o equal to 0.02 or 0.15, respectively [3]. The above values of the probabilities were greater than the probability of a collision with the Earth of a planetesimal migrated from the zone of the giant planets in the Solar System. The latter probability (per one planetesimal) was typically less than 10^{-5} [6]. A lot of icy material and volatiles could be delivered to planets *b* and *d*. The amount of material delivered from the feeding zone of planet *c* to planet *d* could be about twice less than that delivered to planet *b*.

Motion of planetesimals in the outer part of the Hill sphere of the star: About 90% of the planetesimals that first reached 500 AU from the star, for the first time reached 1200 AU from the star in less than 1 million years [4]. The inclinations of orbits of 80% of the planetesimals that moved between 500 or 1200 AU from the star did not exceed 10°. The strongly inclined orbits of bodies in the outer part of the Hill's sphere of the star Proxima Centauri can only be mainly due to the bodies that came into the Hill's sphere from outside. The radius of the Hill's sphere of the star Proxima Centauri is by an order of magnitude smaller than the radius of the outer boundary of the Hills cloud in the Solar System and is two orders of magnitude smaller than the Hill radius of the Sun. Therefore, it is difficult to expect the existence of such a massive analogue of the Oort cloud near this star as near the Sun.

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References: [1] Marov M.Ya, Ipatov S.I. (2023) *Physics – Uspekhi* 66: 2-31. https://doi.org/10.3367/UFNe.2021.08.039044. [2] Ipatov S.I. (2023) *Solar System Research* 57:236-248. DOI: 10.1134/S0038094623030036. [3] Ipatov S.I. (2023) *Meteoritics & Planetary Science* 58: https://doi.org/10.1111/maps.13985. [4] Ipatov S.I. (2023) *Solar System Research* 57. N 6, in production. [5] Levison H.F., Duncan M.J. (1994) *Icarus* 108:18-36. [6] Ipatov S.I. *14th Europlanet Science Congress* 2020. EPSC2020-71. https://doi.org/10.5194/epsc2020-71.