SOLAR SYSTEM SMALL BODIES APPROACHING NEARBY STAR SYSTEMS

Roman Nagy[1], Filip Janák[1], Mária Hajduková[2], and Luboš Neslušan[3]

[1] Faculty of Mathematics, Physics, and Informatics, Comenius University, Bratislava, Slovakia
[2] Astronomical Institute, Slovak Academy of Sciences, Bratislava, Slovakia
[3] Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovakia

Introduction

Exchange of material between stellar systems has a low probability because of the vast distances between stars, although it cannot be excluded. Free-floating bodies in interstellar space are a natural byproduct of planetary system formation. These objects move around the Galactic center and may encounter neighboring stars, as demonstrated by three such objects observed during their passage through the Solar System. Here, we investigate the opposite scenario: the possibility that small bodies ejected from the Solar System may reach neighboring stars in the future.

Data used

- **Stellar catalogues**:
  CNS5 Catalog [1], TESS Catalog [2], and Gaia FLAME [3]
  Final sample: 3 545 stars with full dynamical and mass information

- **Cometary catalog**: CODE Catalog [4, 5] obtaining 123 hyperbolic comets with multiple orbital solutions
  Final sample: 255 cometary orbits

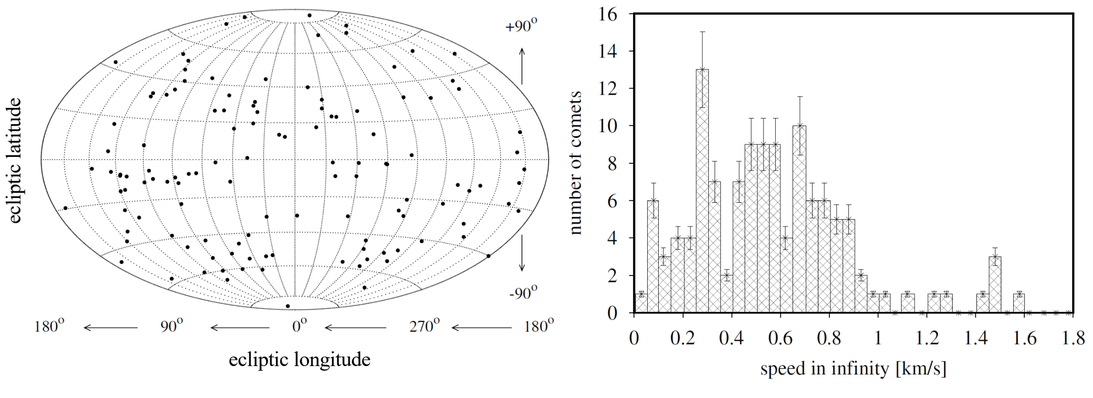


Fig.1 Directional and speed distribution of the sample of comets escaping the Solar System

Methods

The trajectories of real cometary nuclei and hypothetical meteoroid particles were integrated numerically in the Galactic potential for 5 Myr. To estimate the precision of the integration, we simultaneously used two integration algorithms: the Runge-Kutta method and the Leapfrog symplectic integrator [6].

To mimic realistic release conditions while ensuring feasible encounters for meteoroids, we considered test particles leaving the Solar System in all directions with a speed of 1.5 km s^{-1}, corresponding to the upper limit of the realistic interval (Fig. 1).

Comets



Results

- Fourteen cometary nuclei from the sample are predicted to approach thirteen stars within 50 000 au.

The closest approach:
comet C/2009 O4 to Star No. 301: r_{min} = 4633 au, V_{sc} = 27.6 km s^{-1}
The minimum encounter speed:
comet C/2004 B1 to Star No. 1731: r_{min} = 16323 au, V_{sc} = 7.0 km s^{-1}

Time span of the closest approaches, $t - t_0$:
from 396 755 to 2 956 542 yr
Heliocentric distance interval of the comets at closest approach, r_h:
from 226 768 to 1 354 840 au

Notes: r_{min}: the minimum distance to the given star at the moment of the closest approach, V_{sc}: the speed of the comet relative to the star in the moment of the closest approach, $t - t_o$: time elapsed from the present to the moment of the closest approach, and r_h: heliocentric distance of the comet at the moment of the closest approach to given star.

Star No. 2037 – we confirmed a previous prediction of its close encounter with the Solar System's Oort Cloud of comets [7].

Meteoroids

Results

- Five stars were reached by ejected Solar System meteoroids within 10 au

Star identification number		M	V_{sc}	$t - t_o$
CNS5 ID	*Gaia* DR3 ID	($M_\odot$)	(km s^{-1})	[Myr]
Initial particle's speed equal to 1.50 km s^{-1}				
1535	3325157736332326784	0.2311	6.9	2.630
1947	5537221685127063040	0.1934	6.1	3.975
1998	681999884156922368	0.5715	16.5	1.086
2679	5353126879893514368	0.1715	15.3	1.269
4536	4270814637616488064	0.62	12.9	1.444

Notes: M: the mass of star; V_{sc}: the speed of the particle relative to the star in the moment of the closest approach, ignoring the gravity of the star; $t - t_o$: time elapsed from the present to the moment of the closest approach.

Star No. 4536 (Gliese 710) – we confirmed a previous prediction of its close encounter in the future [7,8].

For more details, see **Neslušan et al. (2026), A&A, 708, A309**.

Conclusions

Our results indicate that only a very small amount of material from the Solar System can be delivered to the inner planetary regions of other stellar systems.

A rigorous estimate is not possible due to uncertainties in the initial stellar parameters, particularly the radial velocities.

References

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