Internship in ESA's Advanced Concepts Team
On
Revisiting Debris evolution models: validating gas kinetic theory to model collision risks in orbital environments

European Space Research and Technology Centre
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Candidates interested are encouraged to visit the ESA website:
https://www.esa.int/gsp/ACT/about/jointheteam/

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Topic description

Due to collisional dynamics continuously creating new debris, the simulation of the long term evolution of a given orbital environment (e.g. Low Earth Orbit) is typically time consuming. Any deterministic collision detection method has typically a complexity which is superlinear and thus not ideal for the ever growing numbers of orbiting objects to consider. Furthermore, the orbital dynamics is simulated with great accuracy even when the collision risk has a much lower frequency.

A possible alternative, commonly considered as state-of-the-art in terms of speed, is the use of the Cube algorithm [1] which, albeit probabilistic and based on the kinetic theory of gases, has a linear complexity. While some past studies have been made on the quality of the predictions coming from such a model, as of today there is no convincing result which validates the actual predictions made by Cube against an actual ground truth. A further significant criticism to the Cube algorithm is directed towards its binning strategy which is bound to leave out possible collisions.

This internship will revisit the problem of modelling the long term evolution of debris clouds.

Candidate's task

First, a few fully deterministic simulations [3] of the (say) Low Earth Orbit environment will be performed using tools developed in the Advanced Concepts Team. The Cube algorithm will be used to simulate the same orbital evolution. A comparison between the two set of results will highlight possible critical points on the use of a probabilistic modelling.

Secondly, a N-body simulation (made using the heyoka open source project) will be used to count the collisions of a large number of N isotropic gas molecules [2] confined in a unit cube. Such a ground truth will be used to tune and correct for the underestimation resulting from the Cube binning strategy, assuming it as a constant skew in the collision probability. An updated Cube algorithm will be proposed and tested against fully deterministic simulations of orbital environments.

Joining the ACT

Creativity and out-of-the-box thinking are essential in the ACT. Therefore, the team is constantly striving to be a diverse, inclusive and equitable workplace bringing together people from various backgrounds. We strongly encourage people from under-represented groups to apply to be part of our team as diversity is central to our mission and core values.

In order to make our hiring as fair as possible, we also ask applicants to not include photos in their CVs.

References

[1] Liou, J-C. "Collision activities in the future orbital debris environment." Advances in Space Research 38.9 (2006): 2102-2106.

[2] Biscani, F. "The Maxwell-Boltzmann distribution using Heyoka" https://bluescarni.github.io/heyoka.py/notebooks/The%20Maxwell-Boltzmann%20distribution.html (2021)

[3] Gómez, P., et al. "Deterministic Conjunction Tracking in Long-term Space Debris Simulations." arXiv preprint arXiv:2203.06957 (2022).