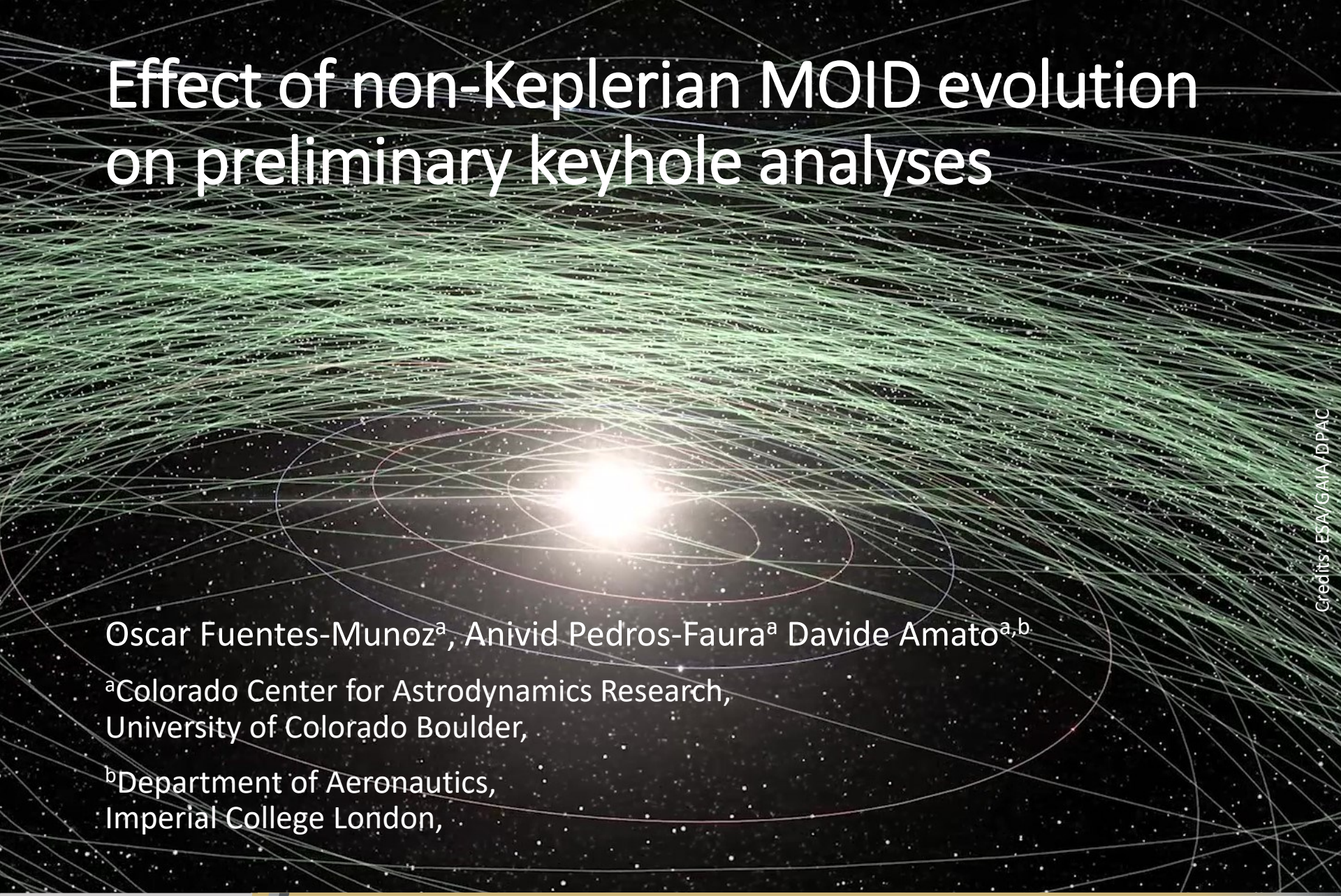
Effect of non-Keplerian MOID evolution on preliminary keyhole analyses



Credits: ESA/GAIA/DPAC

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Resonant encounters - Keyholes

2021 PDC Flyby

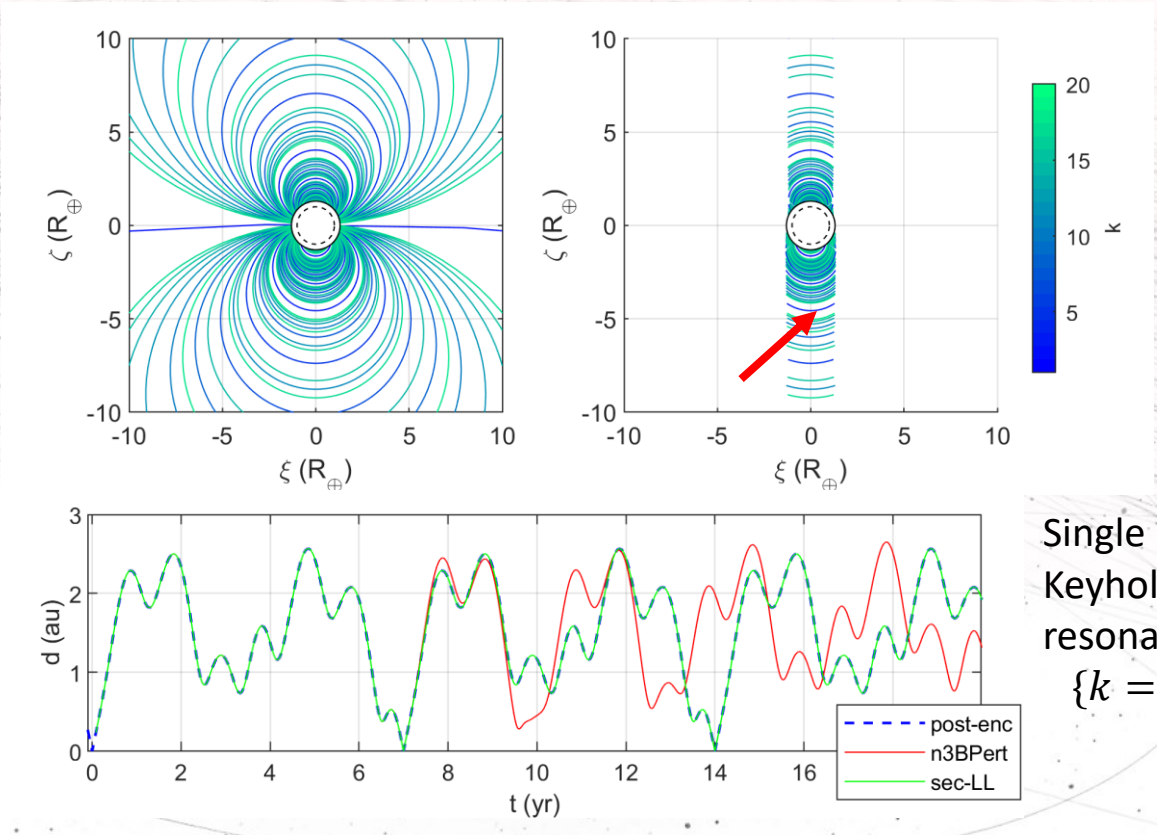
B-plane or Target plane (Öpik frame[1])

*Earth circular and ecliptic

$$kT_p = hT'$$

$$or$$

$$a_R'^{\,3} = a_p^3 \frac{k^2}{h^2}$$



Single point in Keyhole at resonant circle: $\{k = 7, h = 5\}$

[1] D. Farnocchia, S. Eggl, P.W. Chodas, J.D. Giorgini, S.R. Chesley, Planetary encounter analysis on the B-plane: A comprehensive formulation, Celestial Mechanics and Dynamical Astronomy 131 (2019) 36.

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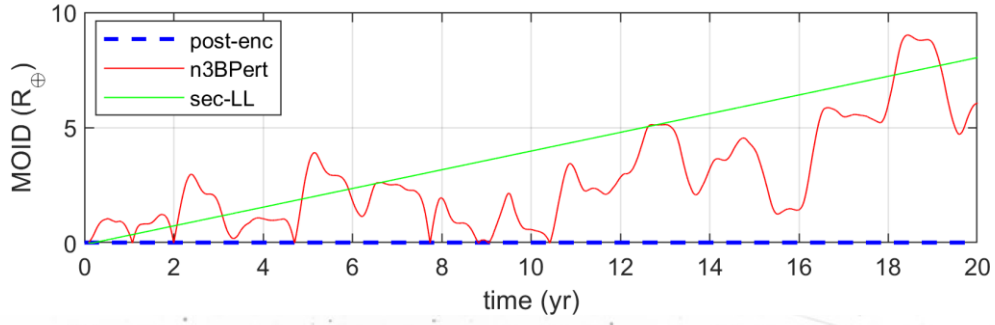
Finding Keyholes[2]

ξ": next encounter
ξ': post-encounter
ξ: pre-encounter

Collision: $\sqrt{\xi"^2+\zeta"^2} \leq \gamma R_p$

- MOID: $\xi" = \xi' + \Delta\xi$
- Timing: $\frac{\partial\zeta"}{\partial\zeta}$

- Secular Perturbation by Jupiter (analytical)
- n_p planet perturbers (num. integration)



Single point in Keyhole at resonant circle: $\{k = 7, h = 5\}$

[2] G. B. Valsecchi, A. Milani, G. F. Gronchi, S. R. Chesley, Resonant returns to close approaches: Analytical theory, Astronomy & Astrophysics 408 (2003) 1179–1196.

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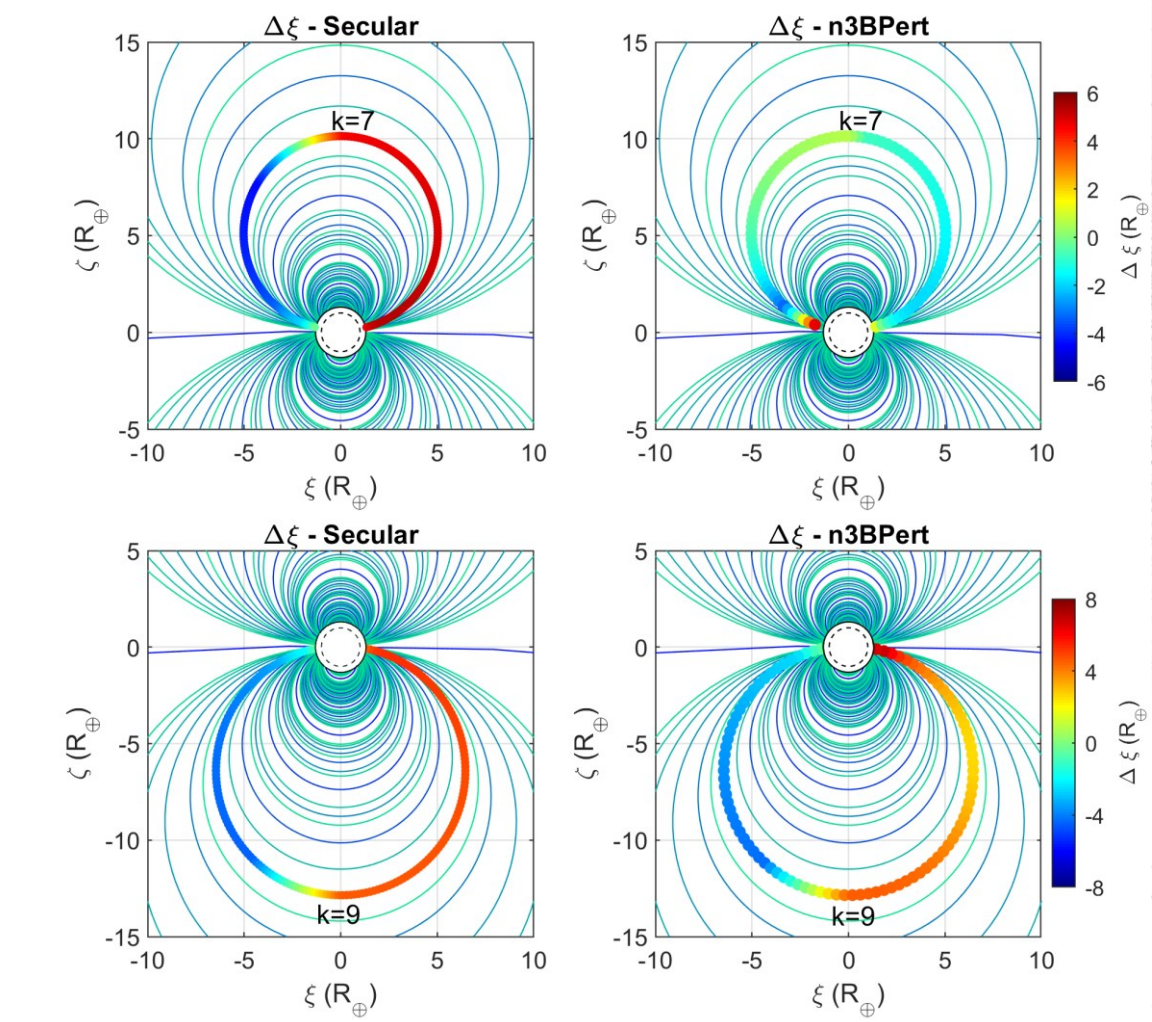
MOID propagation in Resonant Circles



Resonant circle:
$\{k = 7, h = 3\}$

Resonant circle:
$\{k = 9, h = 5\}$

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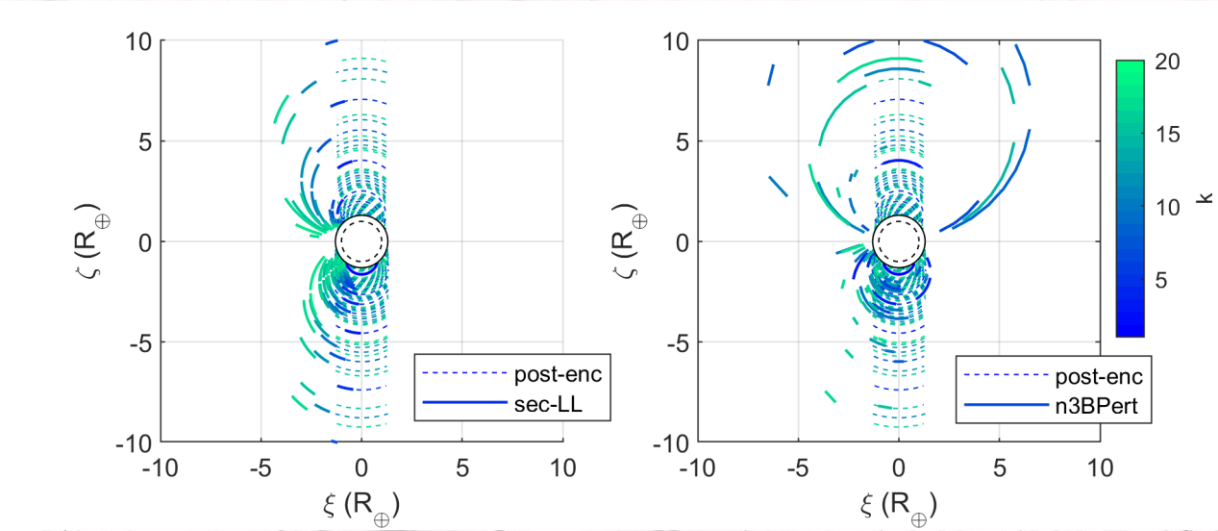
Modified Keyholes



CONCLUSIONS

- MOID time variation influences shape and location of keyholes
- MOID-$\{\xi, \zeta\}$ relationship more complex with realistic Earth orbit
- Room for improvement of the analytical model
- Extension with additional examples required – very case specific

Questions/Comments?
Please contact us
and/or see paper!

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