

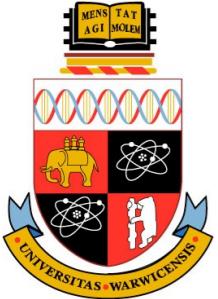


Milton Wainwright

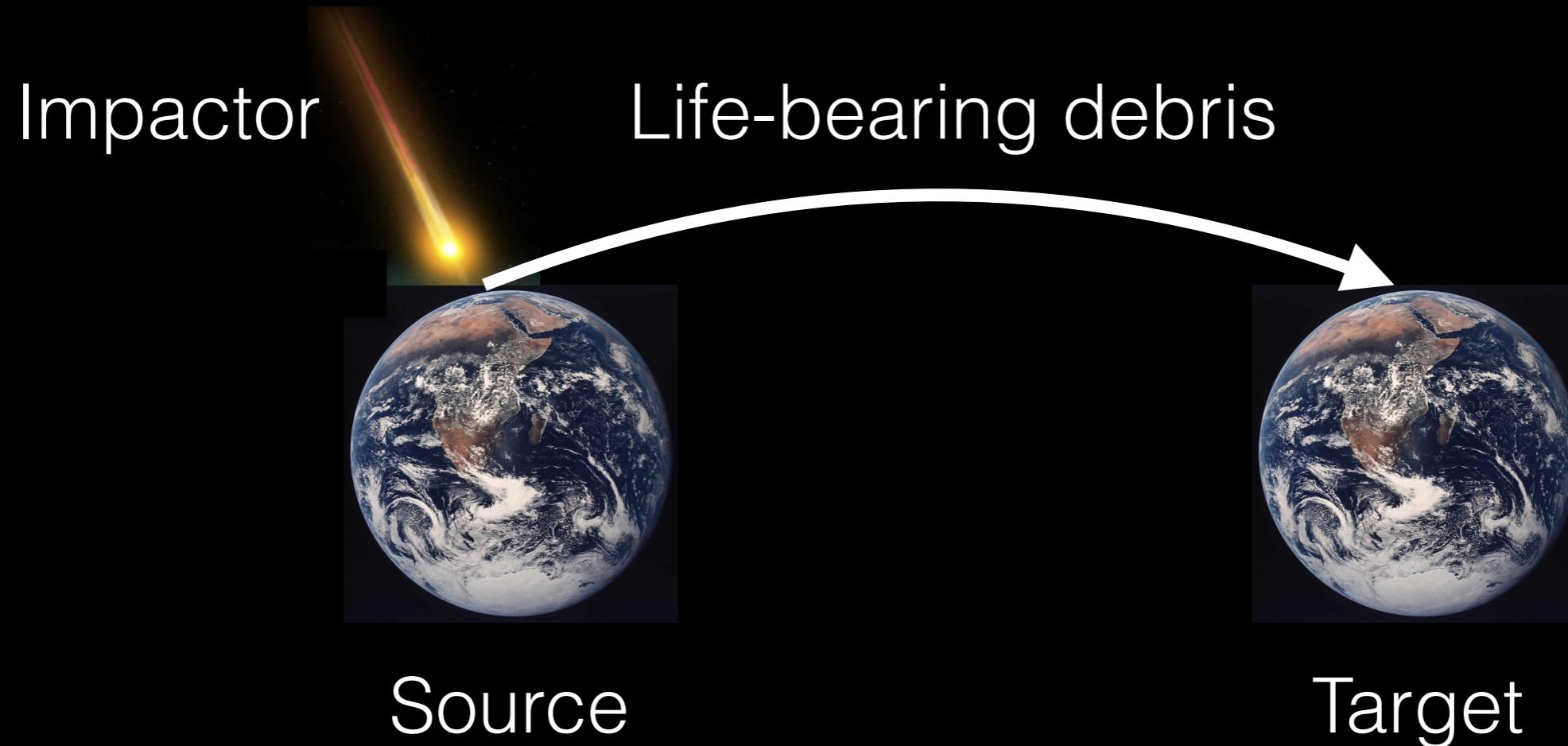
Panspermia in tightly-packed habitable multi-planet systems

Dimitri Veras

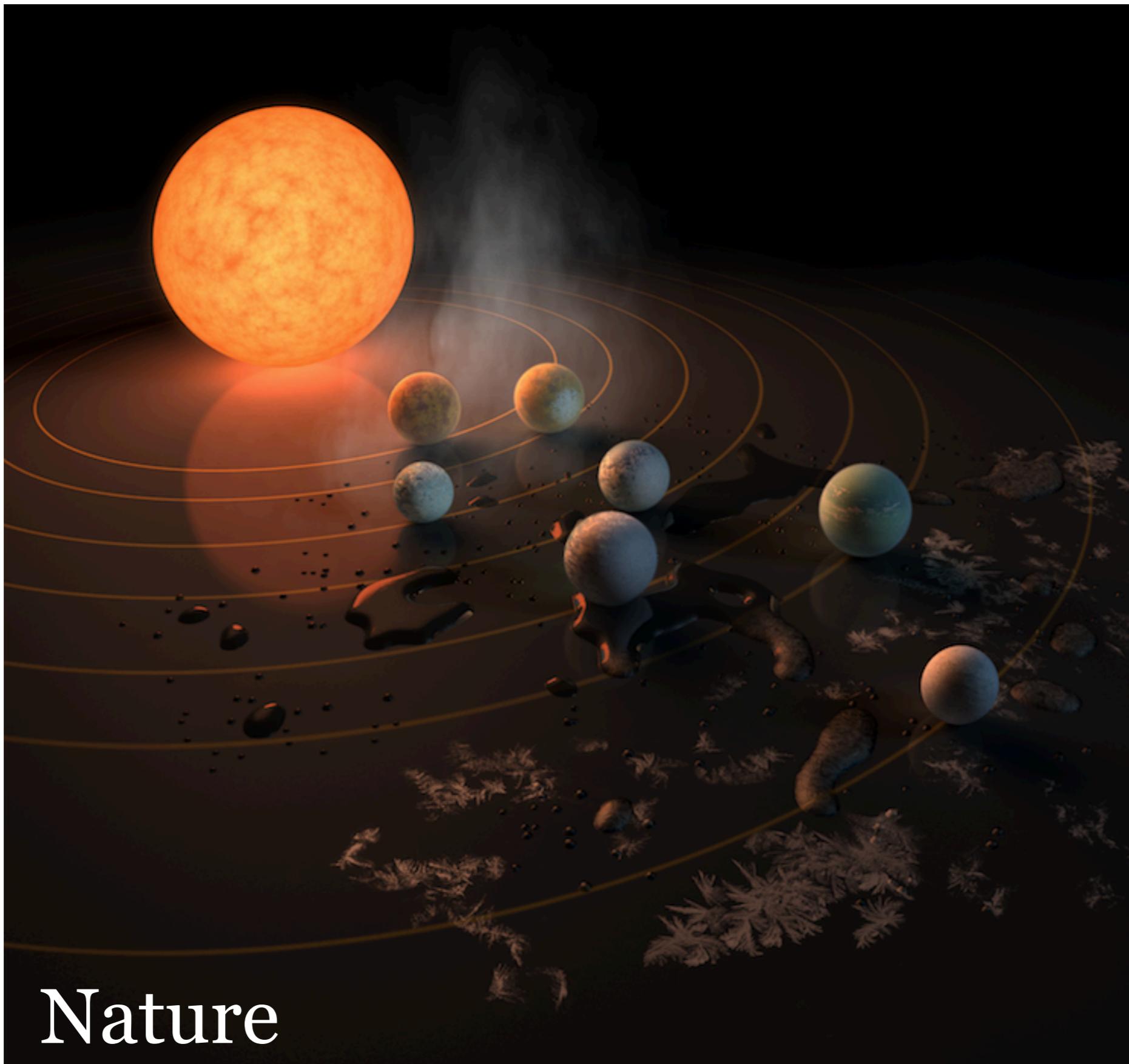
University of Warwick (UK)



Transport mechanism



Motivation: TRAPPIST-1



Nature

Collaborators

Astronomers:

Myself
David J. Armstrong
Alan P. Jackson
James A. Blake

Biologists:

Hendrik Schaefer
Jose F. Gutierrez-Marcos

Center for Exoplanets and Habitability
at the University of Warwick (UK)

Comparison with other studies

Exosystem-specific

Heller & Armstrong (2014)

Steffen & Li (2016)

Krijt et al. (2017)

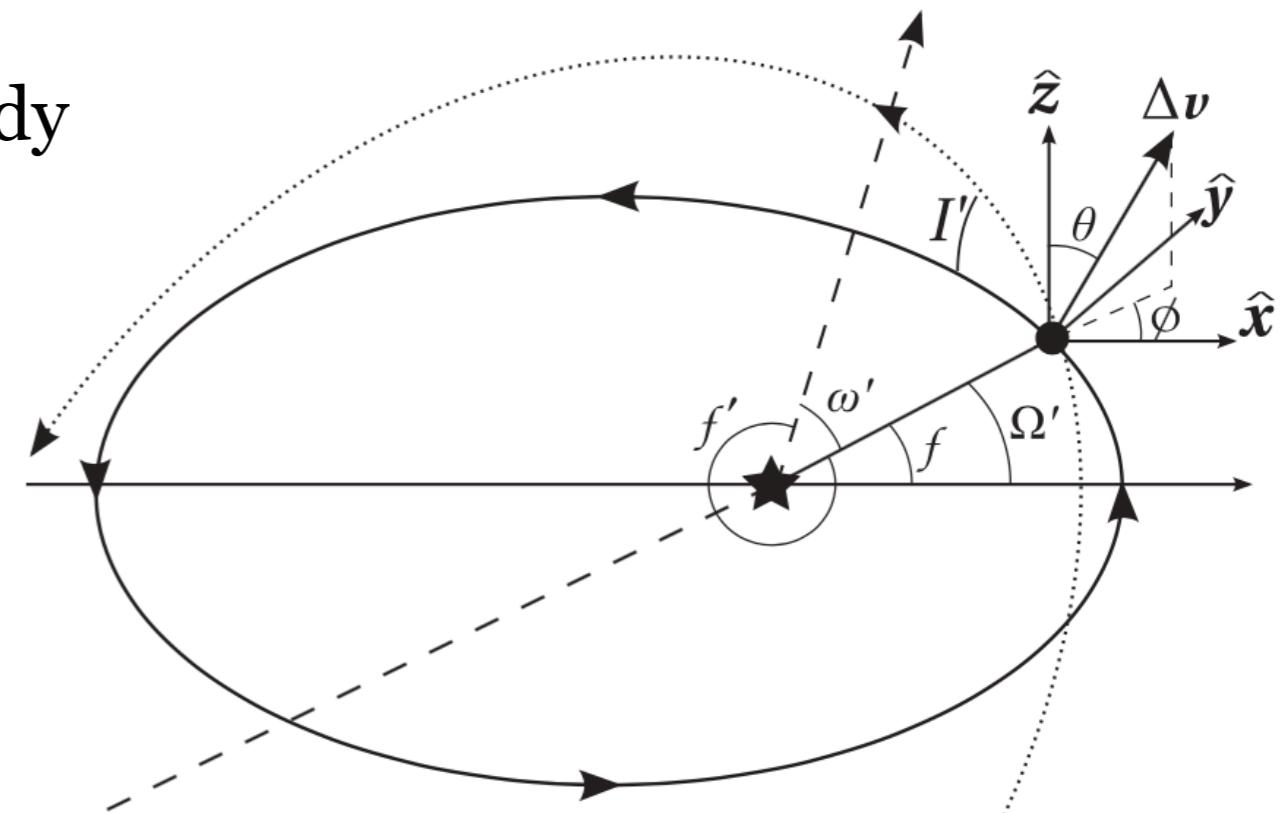
Lingham & Loeb (2017)

General, analytical: explicit expressions

Relies on formalism of
Jackson et al. (2014)

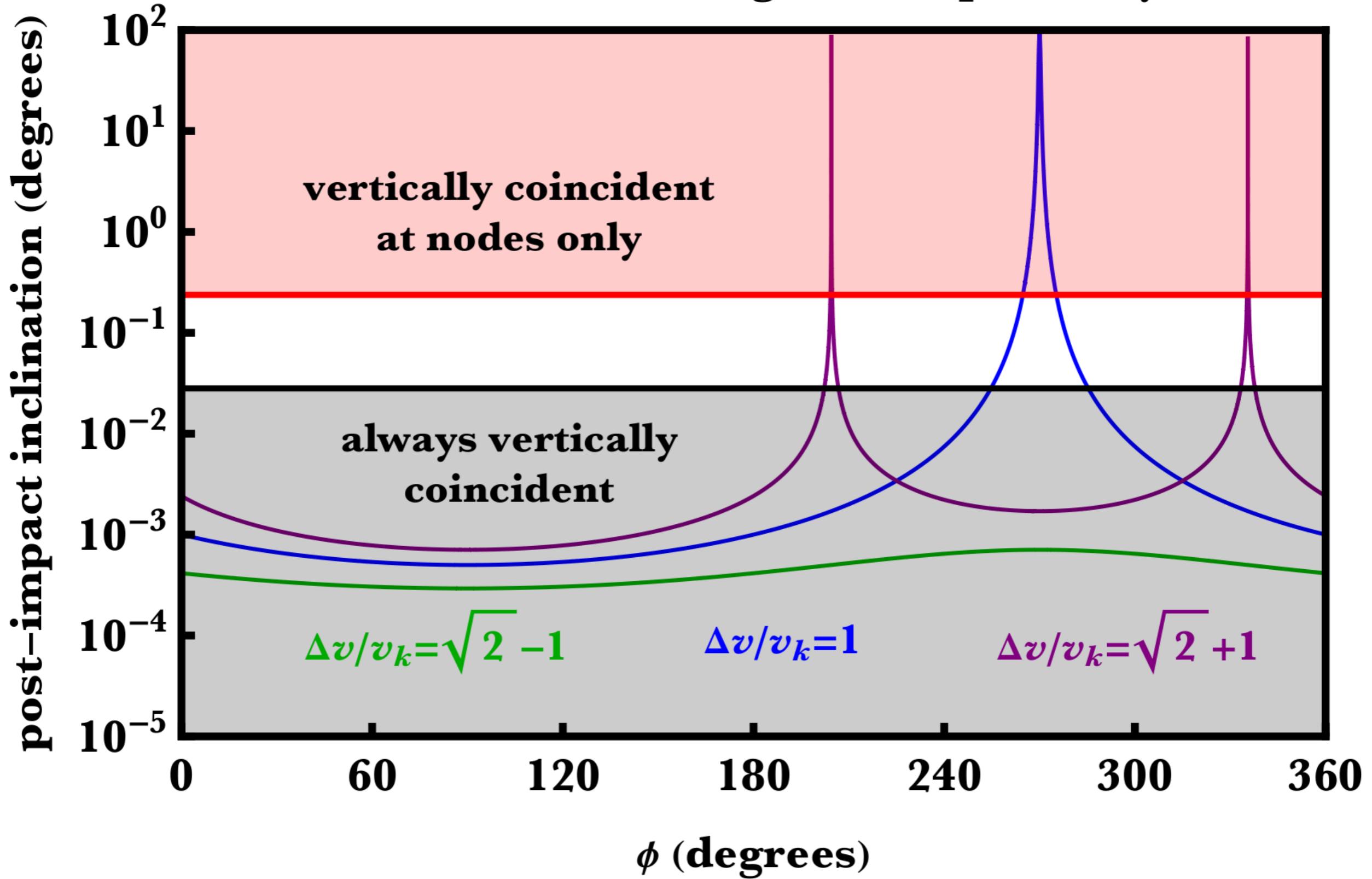


Our study

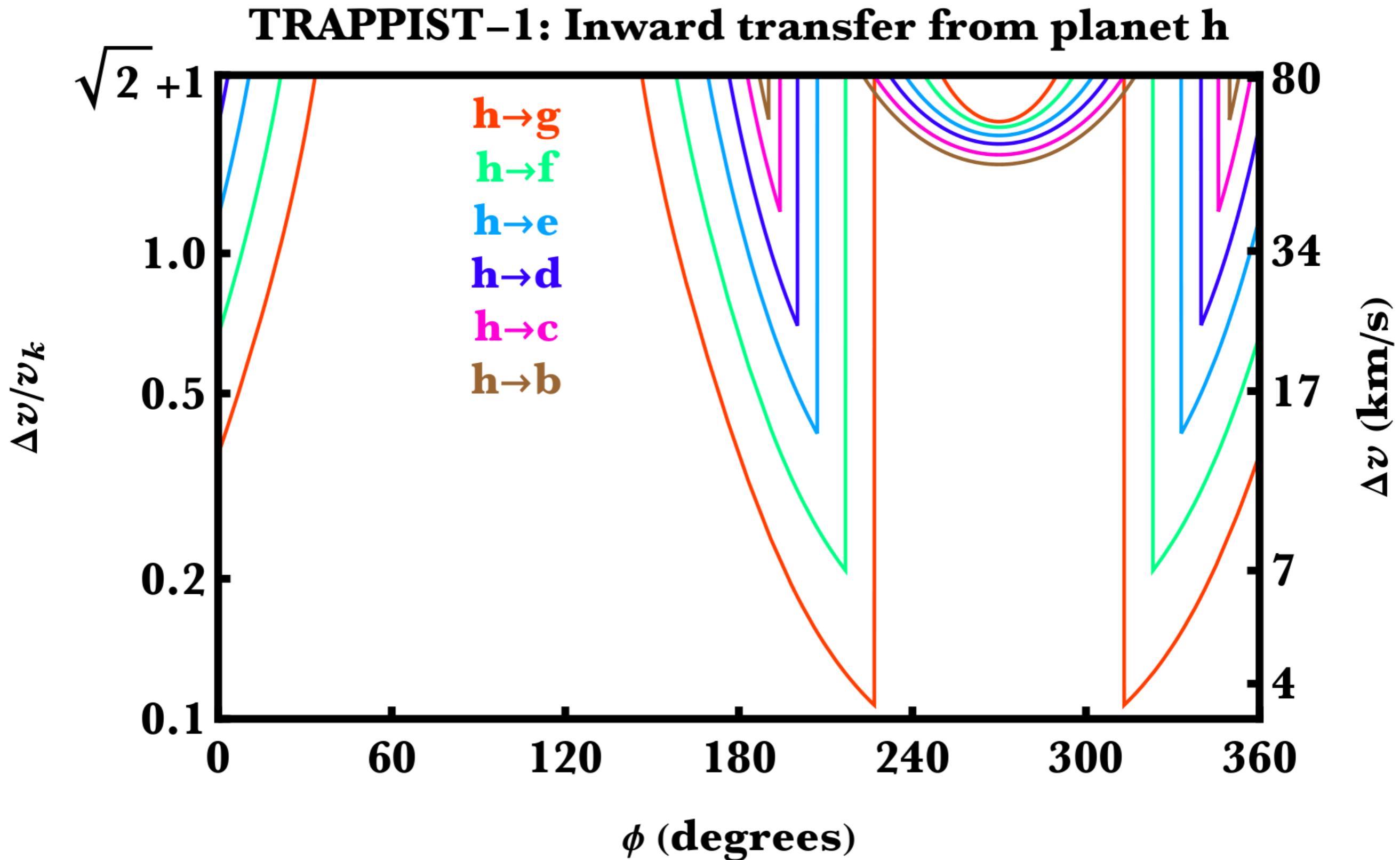


How coplanar?

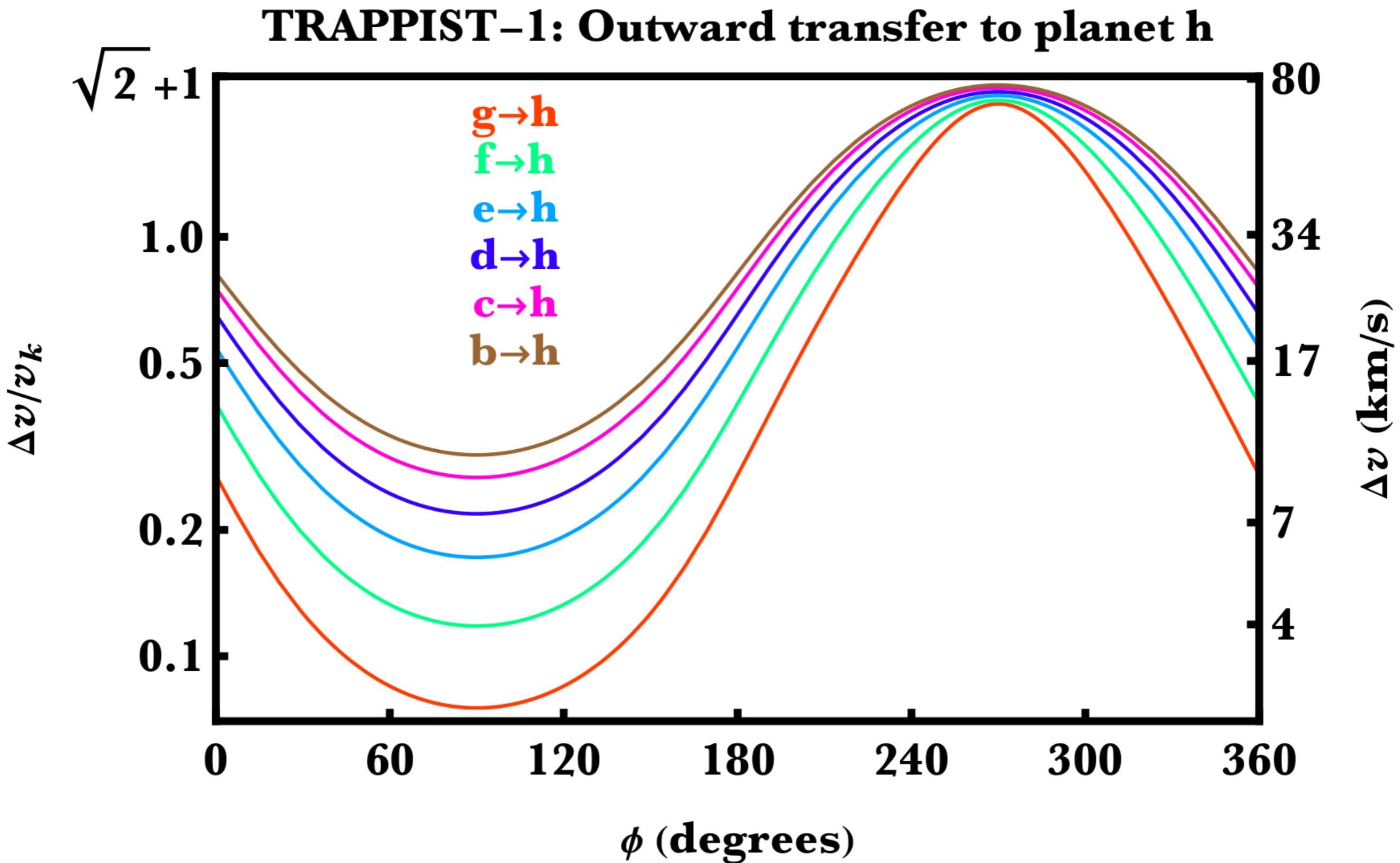
Kick offset 10^{-3} deg from coplanarity



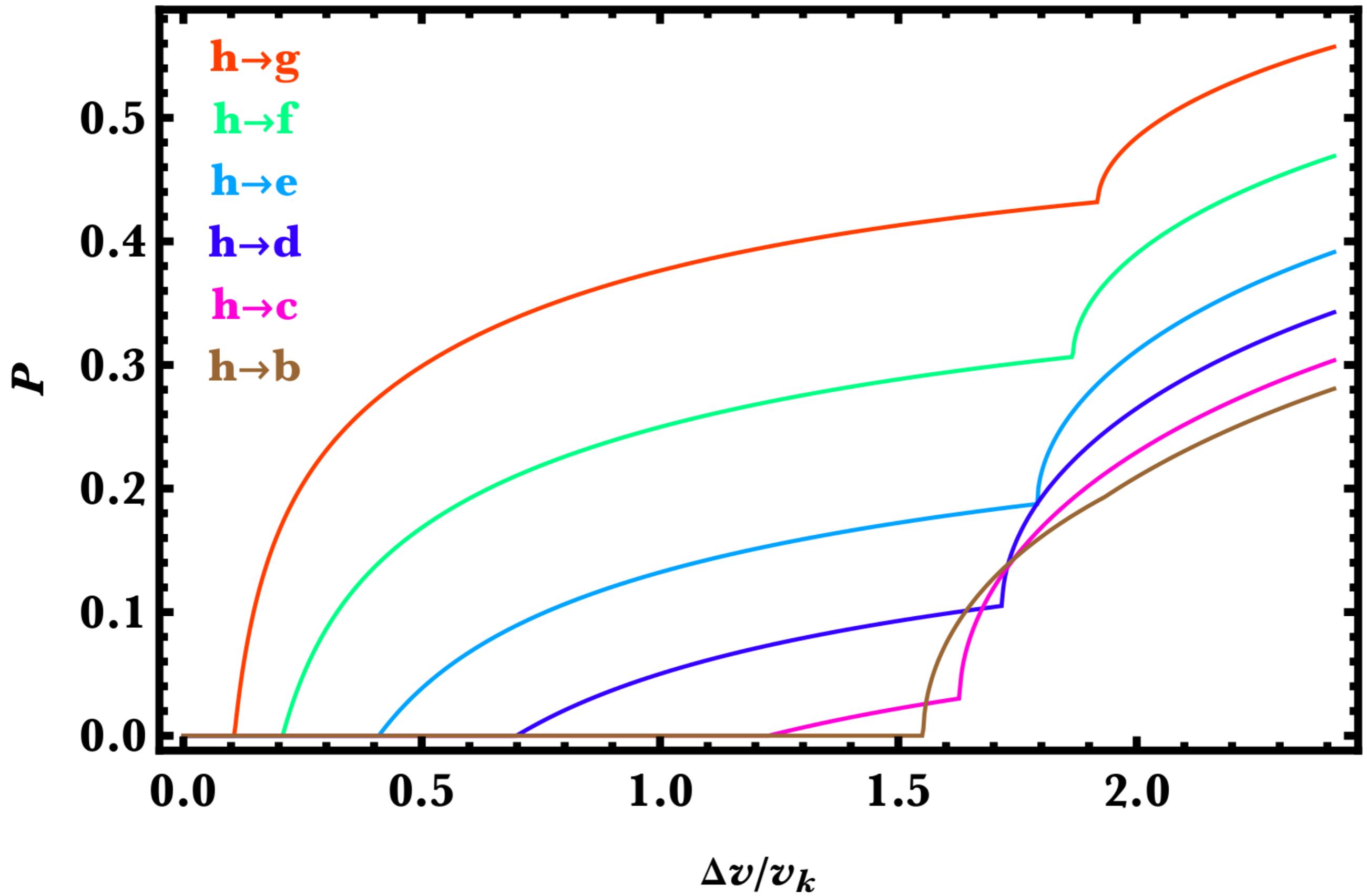
Minimum necessary kick speed



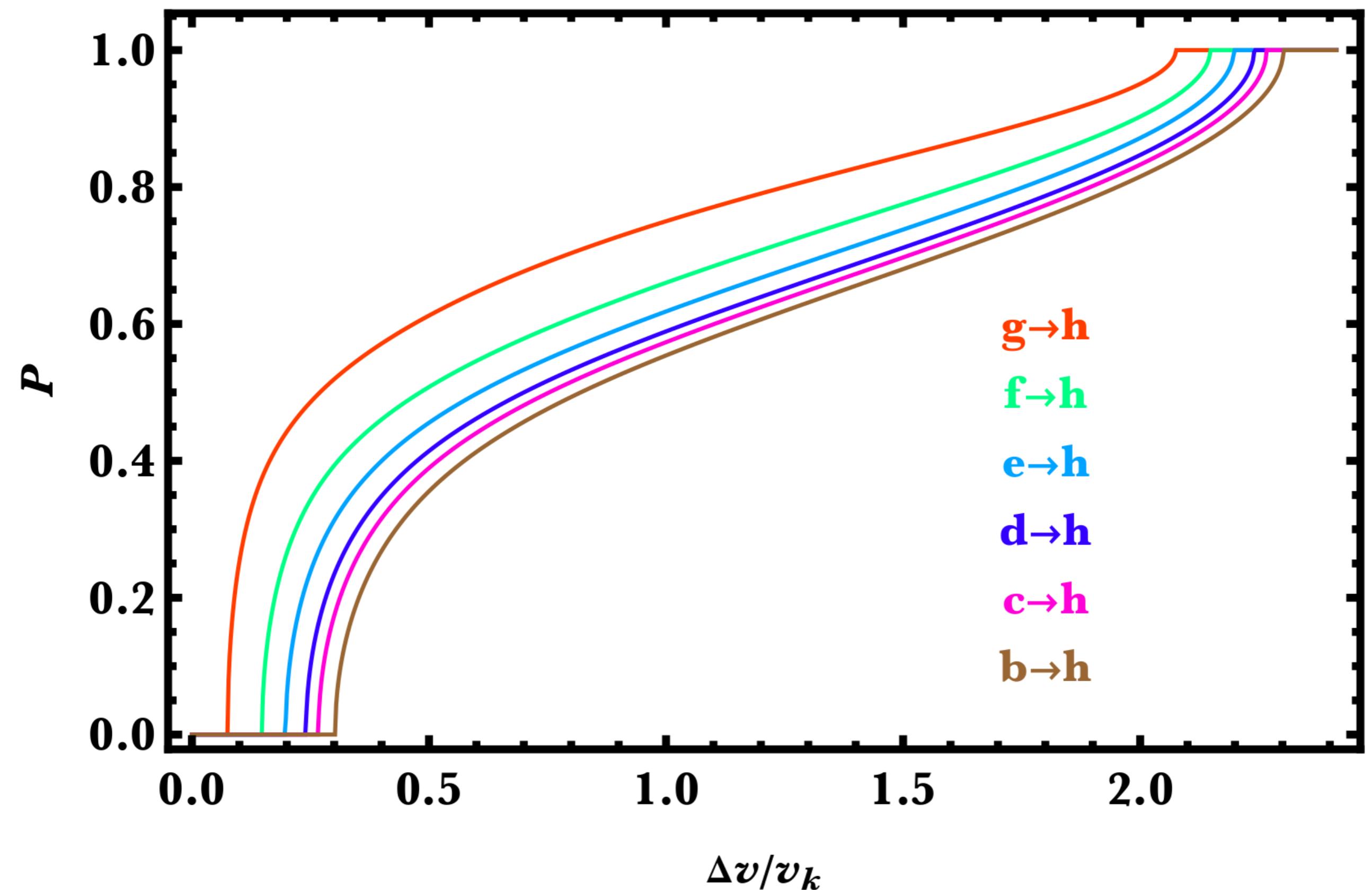
Minimum necessary kick speed



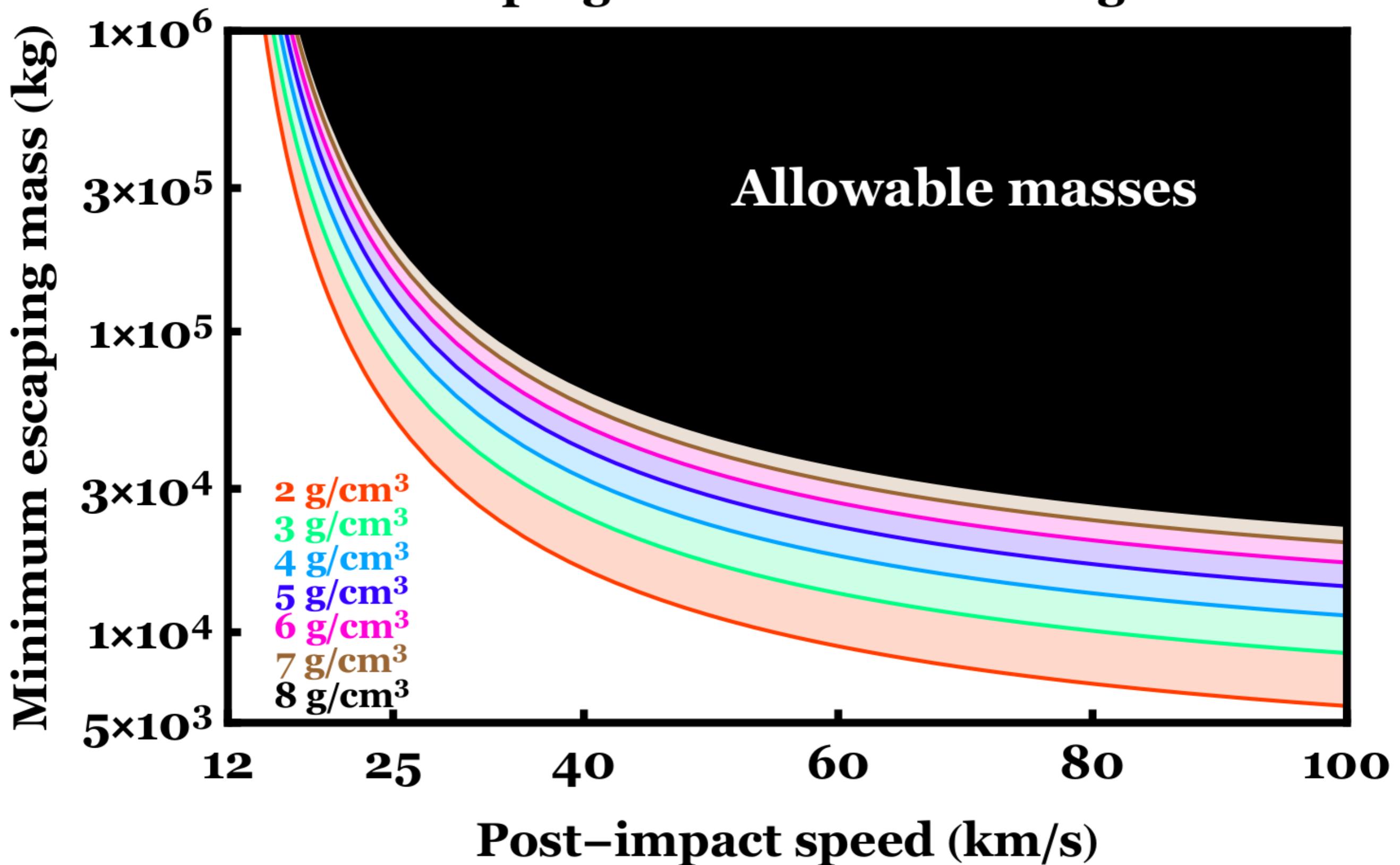
Probability of ejecta intersecting orbit of inner planet



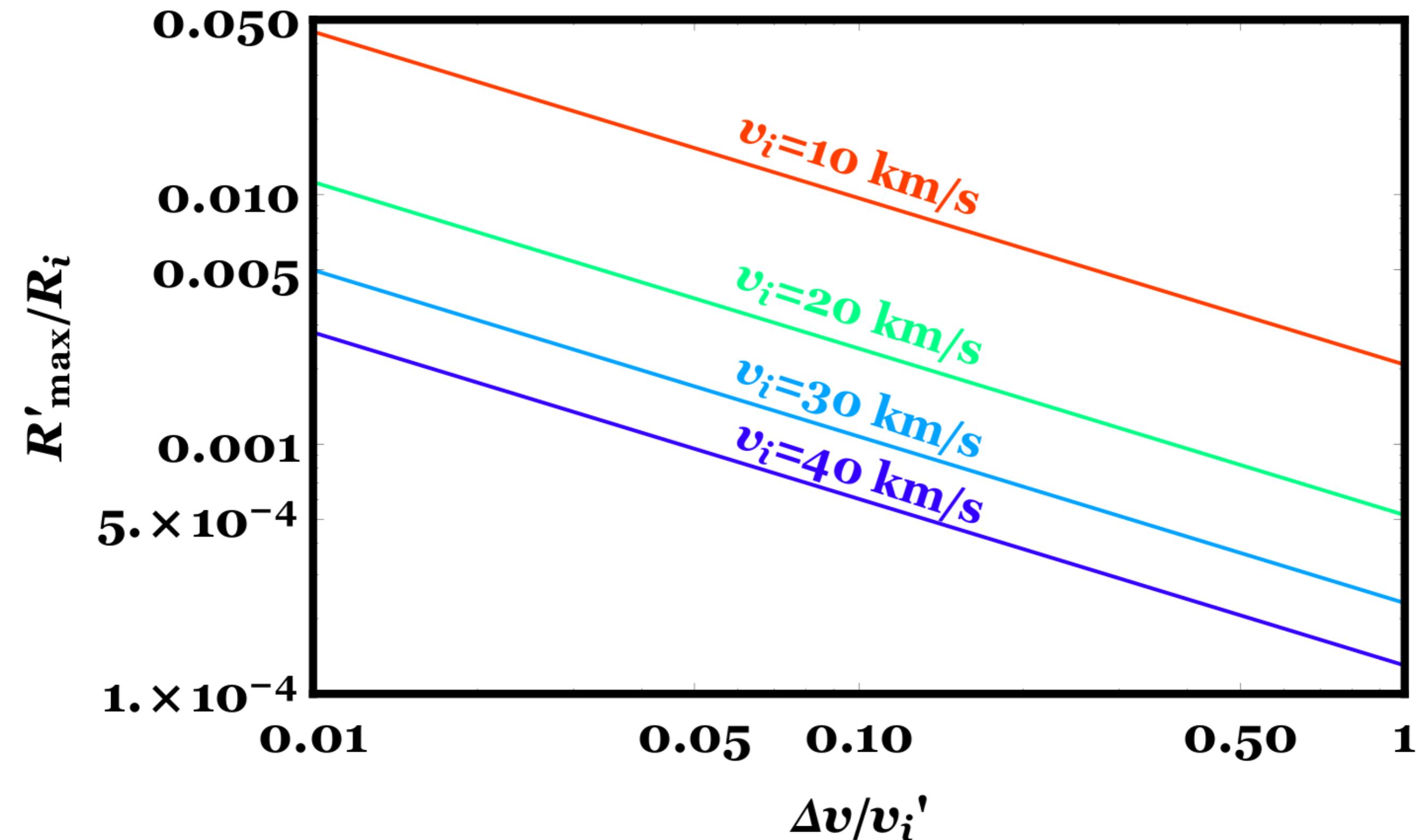
Probability of ejecta intersecting orbit of outer planet



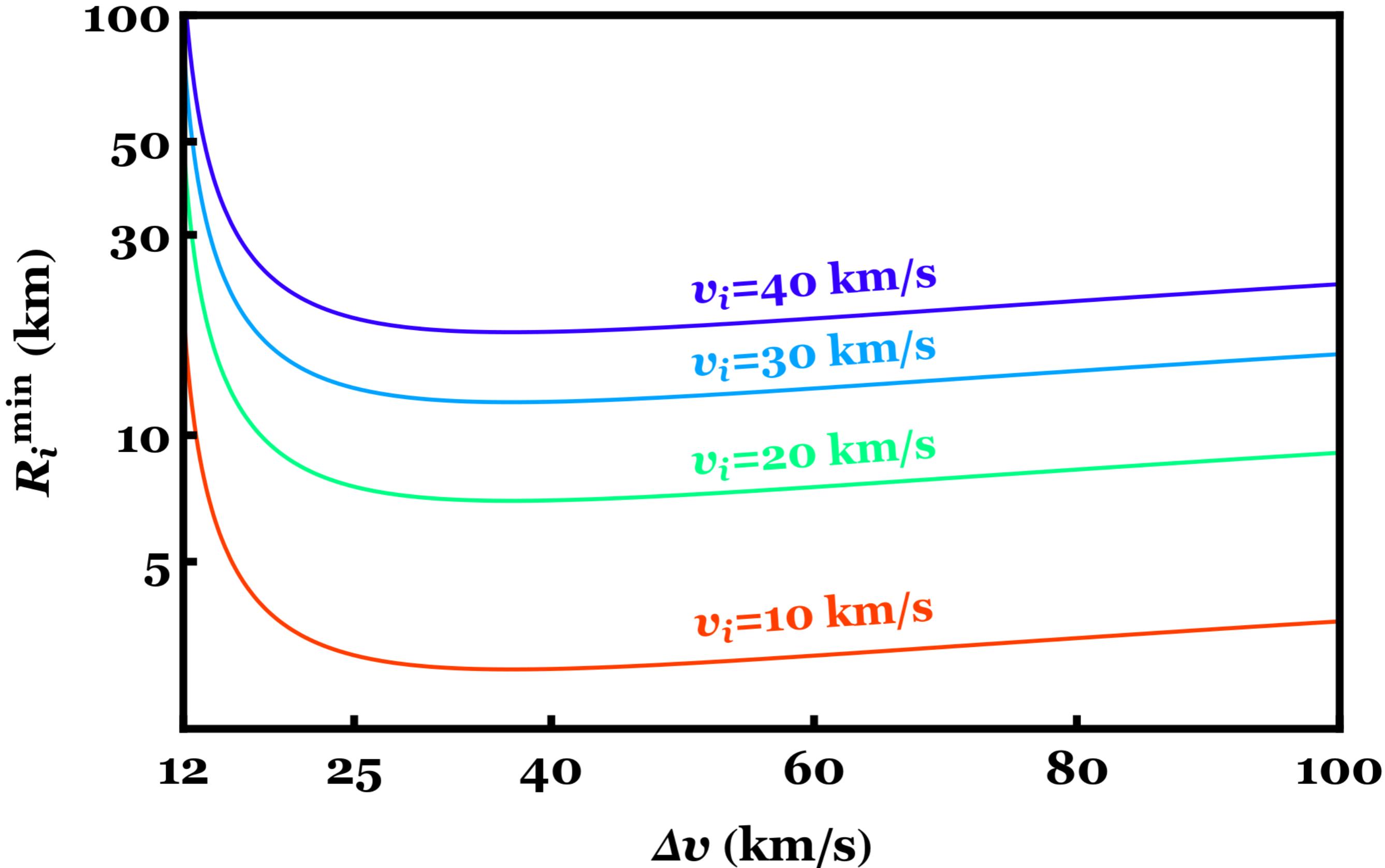
Escaping an exo–Earth analogue



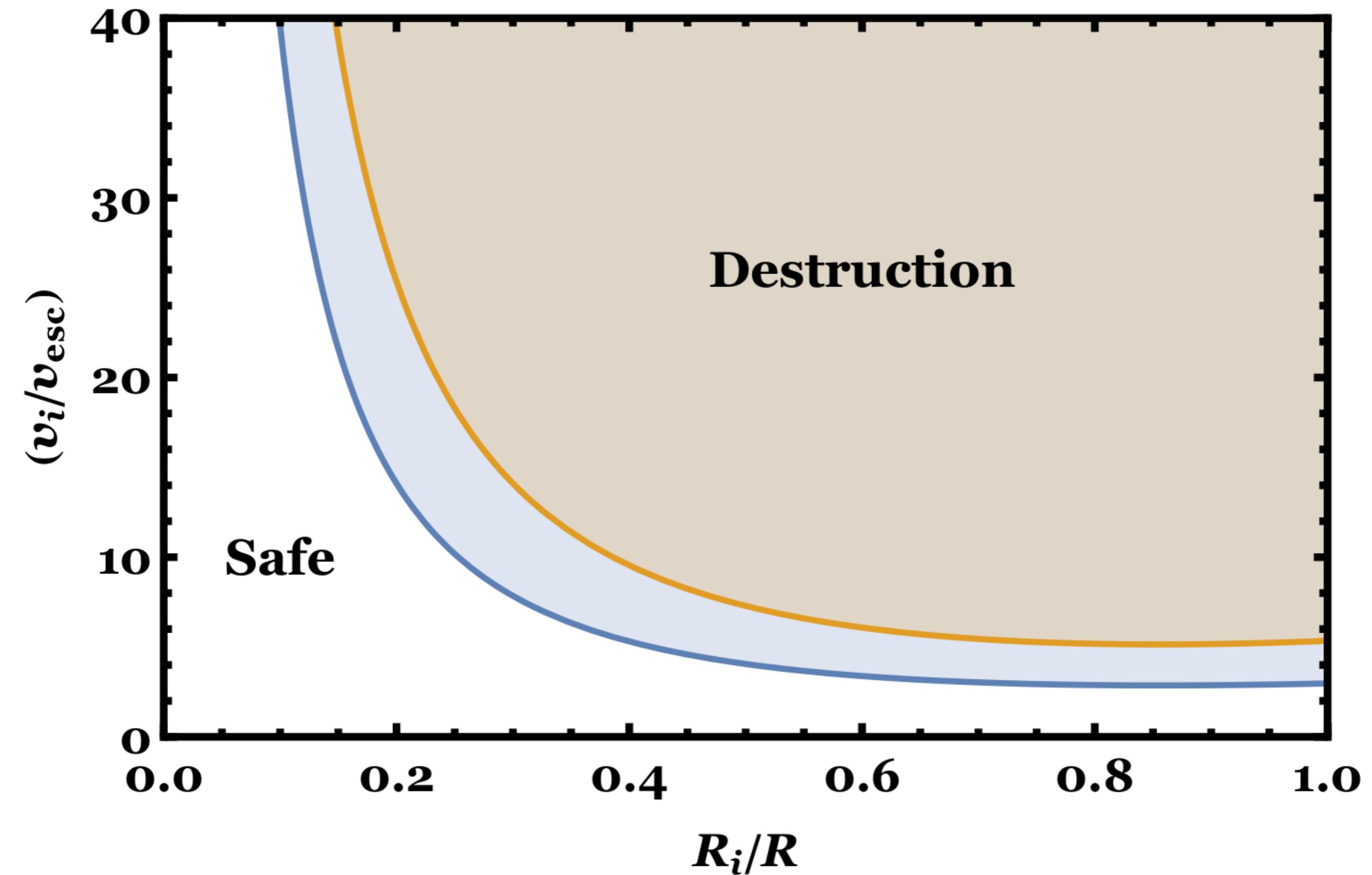
Largest possible fragment for basalt



Minimum impactor size liberating basalt



Catastrophic disruption of source planet

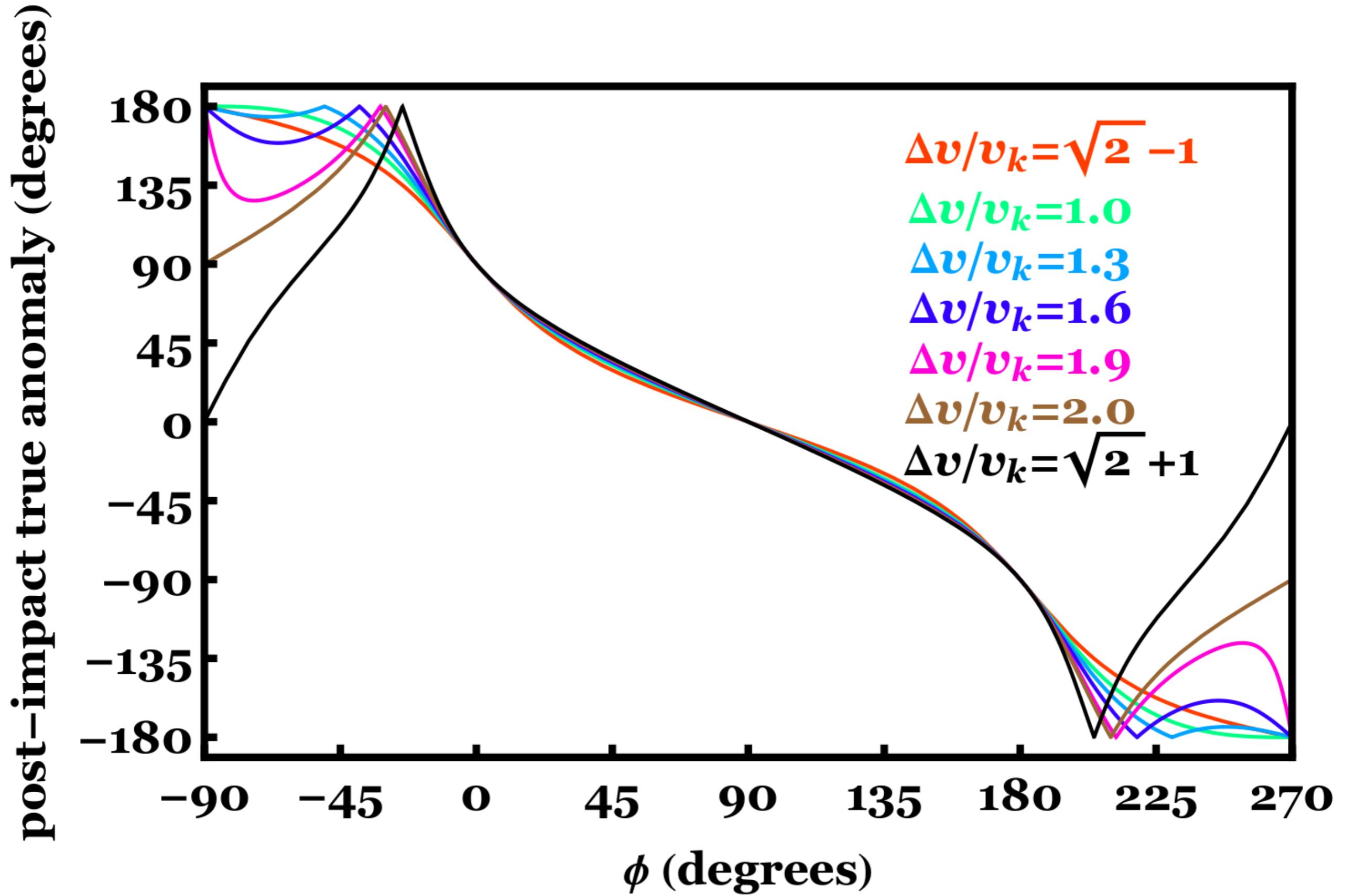


Conclusions

Analytical treatment of exosystem panspermia:

Explicit formulae for:

- Debris paths to seed target planets
- Probabilities for intersecting planet orbits
- Minimum ejecta masses
- Minimum impactor size for ejection
- Largest possible fragments



Kick offset 0.5 deg from coplanarity

