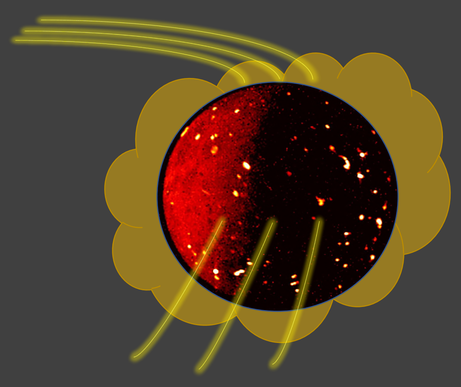

Exo-Io Simulations of Toroidal Exospheres in Alkali Spectroscopy

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Summary

- Although **exomoons**, natural satellites beyond our solar system, are still undetectable in direct searches with state-of-the-art instruments, their existence has been hypothesized to explain various **inconsistencies in exoplanetary spectra**.
- We develop a **3D test-particle Monte Carlo simulation** module called ***SERPENS*** and simulate the **neutral outgassing and evolution of a satellite** at multiple candidate exoplanet-exomoon systems to provide a **number density** and a **line-of-sight column density** map of the evolving particle environment.

Paper:

- Our results demonstrate how exomoons similar to Io, referred to as **exo-Ios**, can affect line-of-sight column densities depending on the phase of the exomoon at the time of observation. Thus, it is possible to **model time-variable spectra by taking into account the phase of the exomoon**.

Introduction & Goals

- Rocky exomoons are very small, so an **active** environment is needed to indicate their presence
  → Signatures in transiting exoplanet spectra and light-curves
- Tidal heating keeps orbit stable
- Predictions for future **high-resolution spectroscopy** by simulating particle evolution

What is an exo-Io ?

Extreme **volcanism** because of **tidal heating**
→ Alkaline **atmosphere**
→ **Sputtering** as mass-loss mechanism
→ Emergence of a **particle torus**

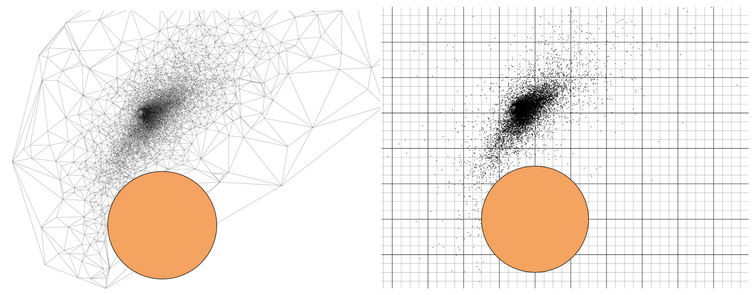
Methods

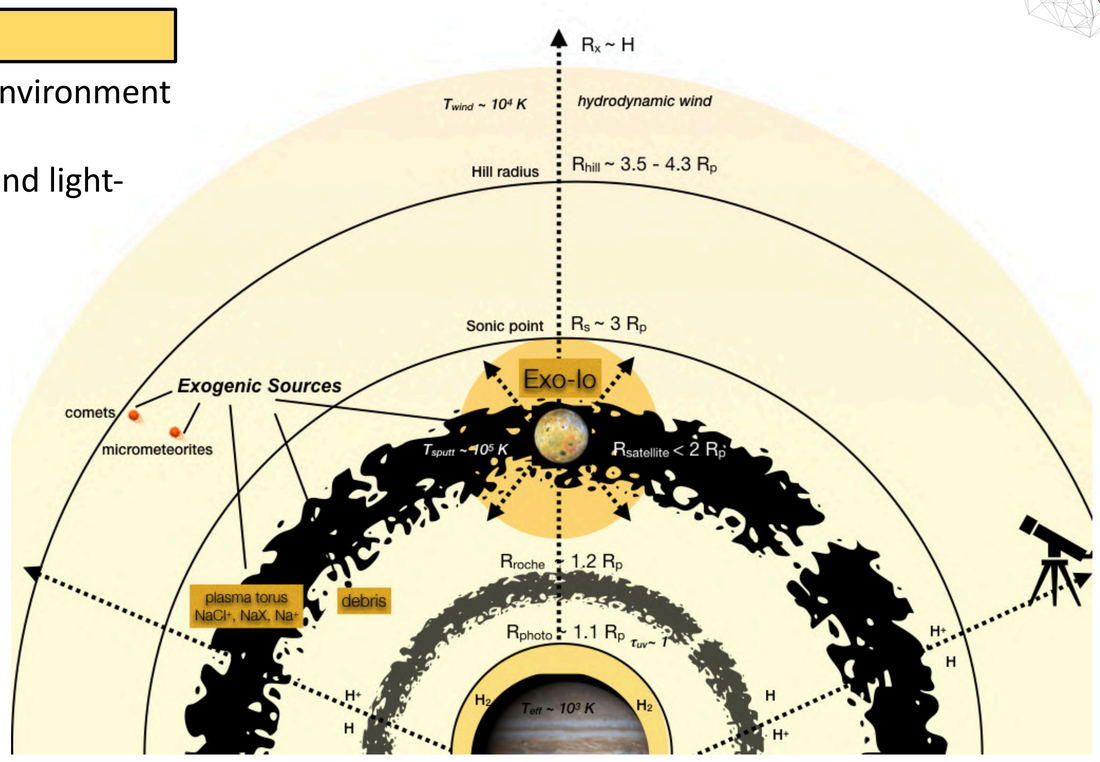
SERPENS

Simulating the Evolution of Ring Particles Emergent from Natural Satellites

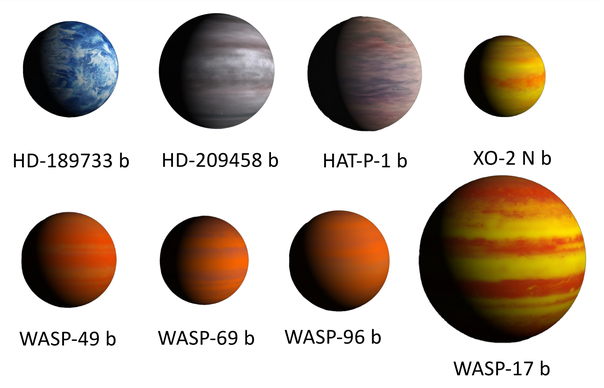
- Test-particle Monte-Carlo simulation
- Open-Source & highly adaptive
  (https://github.com/momzw/SERPENS)
- Focused on neutral particles
- Inclusion of radiation pressure

New Approach to Density Calculation:
The Delaunay Tessellation Field Density Estimation

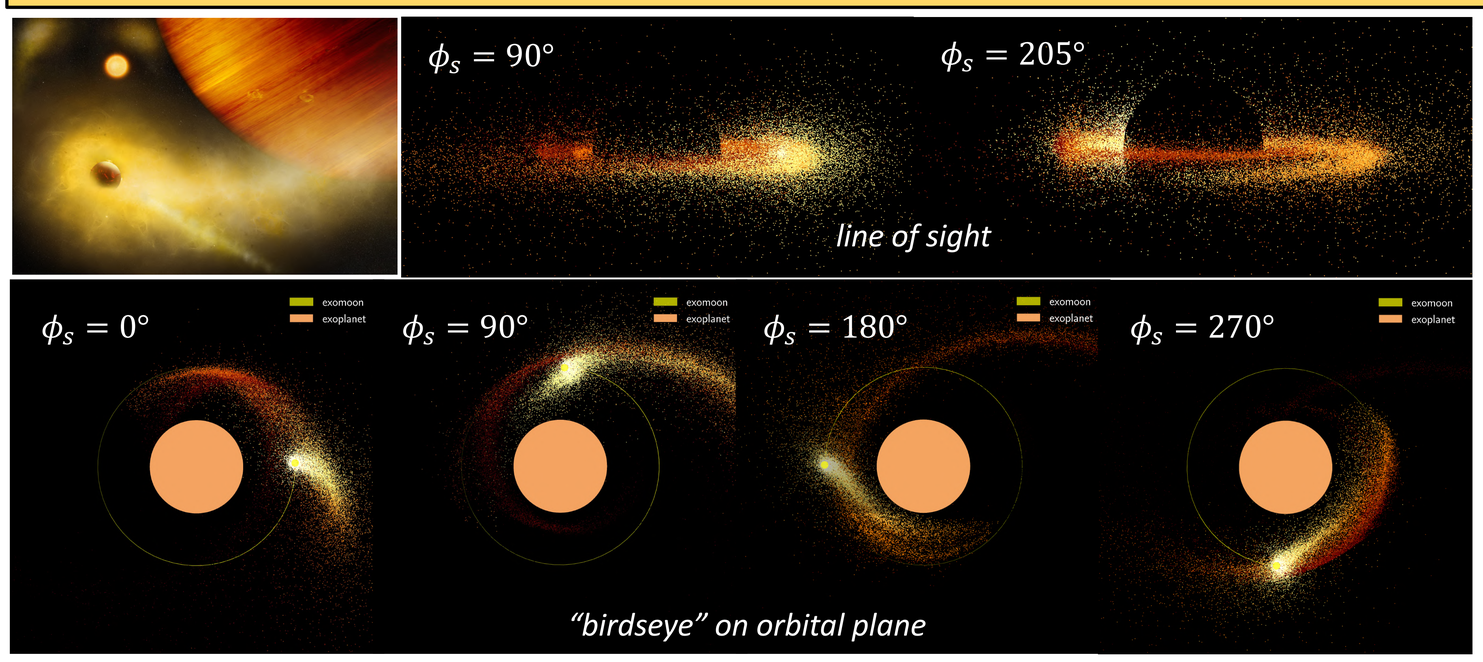




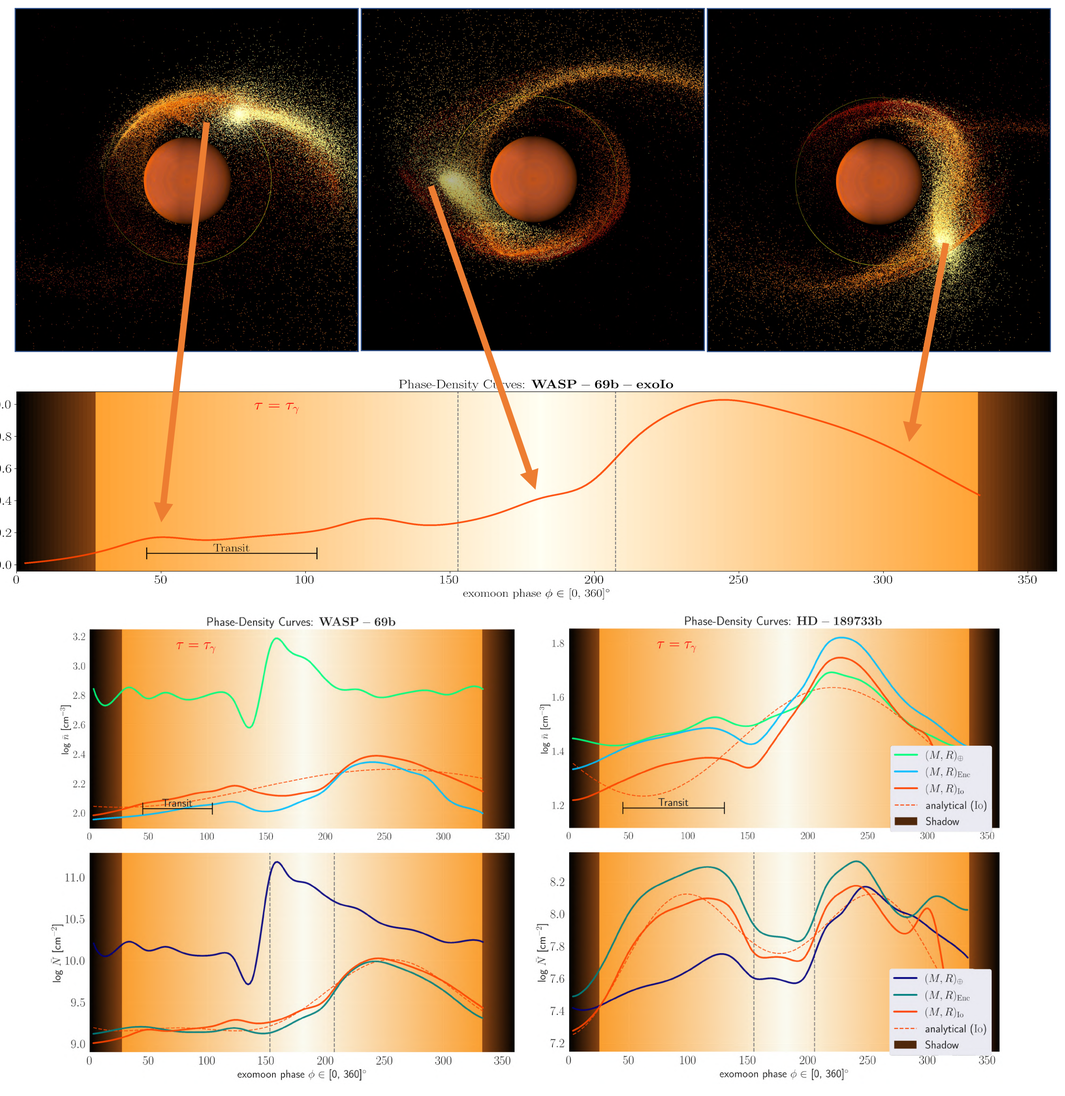
Candidate Systems



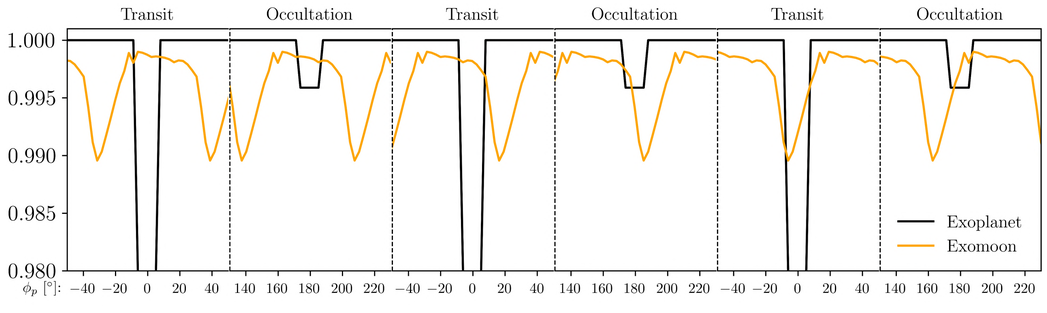
Results



- Toroidal structures emerge if lifetimes of species are long enough or exomoon mass-loss rates are large.
- Continuous evaporation is necessary when intense radiative forces are present.
- Spectral depth variations in transit spectra might be explainable by evaporating exomoons.



Watch our simulations on YouTube!



References

- Oza et al. (2019b). Sodium and Potassium Signatures of Volcanic Satellites Orbiting Close-in Gas Giant Exoplanets
- Johnson & Huggins (2006). Toroidal Atmospheres around Extrasolar Planets.
- Cassidy et al. (2009). Massive satellites of close-in gas giant exoplanets.
- Wyttenbach et al. (2017). Hot Exoplanet Atmospheres Resolved with Transit Spectroscopy (HEARTS) I. Detection of hot neutral sodium at high altitudes on WASP-49b.
- Wilson et al. (2002). The dual sources of Io's sodium clouds.
- Schaap & van de Weygaert (2000). Continuous fields and discrete samples: Reconstruction through delaunay tessellations.
- Gebek & Oza (2020). Alkaline exospheres of exoplanet systems: evaporative transmission spectra.