Spectroscopic observations of Io Neutral Clouds: constraints on Na-bearing dust grains ejected from Io

Cesare Grava[1*], Tim Cassidy[2], Nick Schneider[2], Sean Hsu[2]

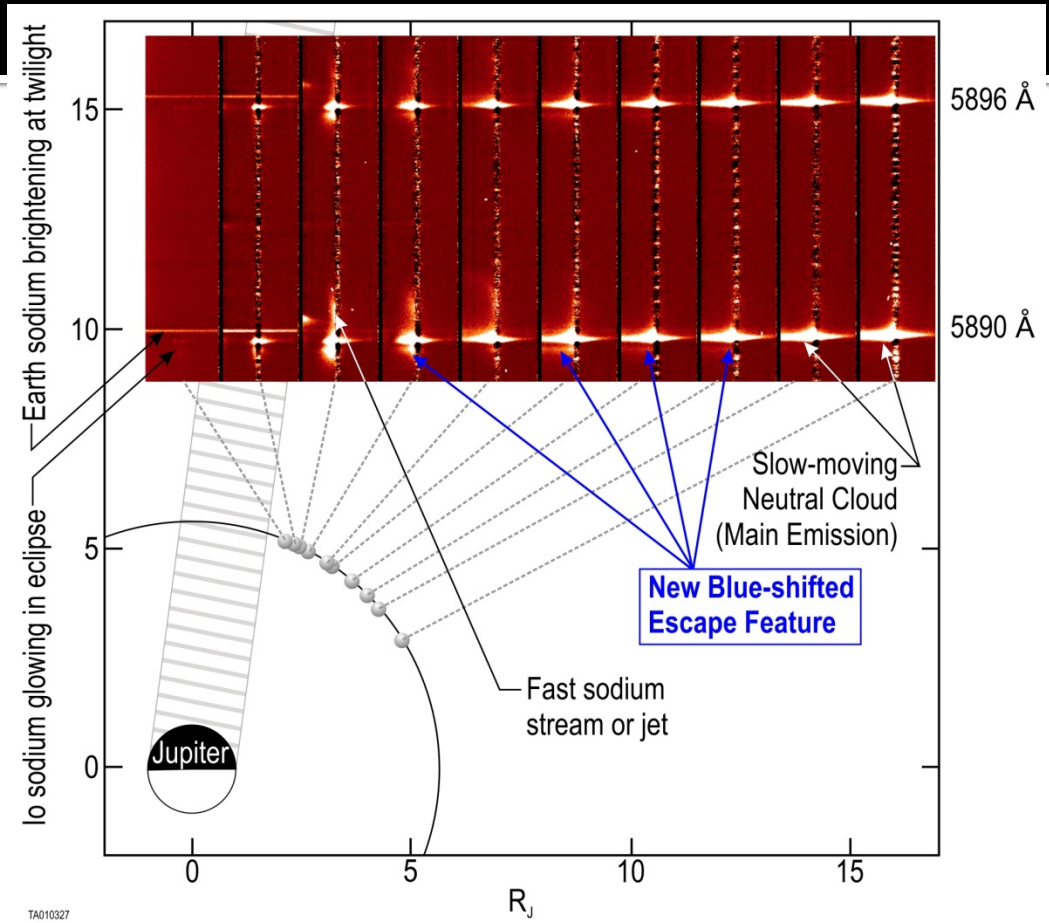
1: Southwest Research Institute

2: LASP – University of Colorado

*cgrava@swri.org

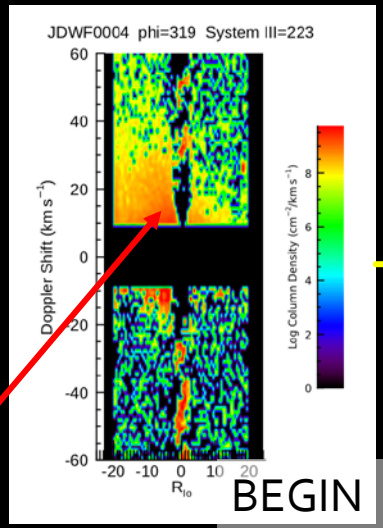
A New Spectroscopic Feature?

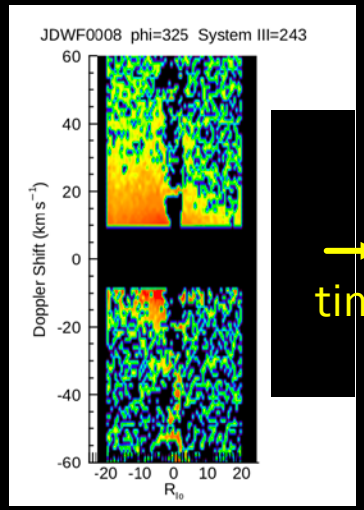
- Detected while observing Io's Neutral Clouds before Jupiter's eclipses (Grava et al., 2014) at TNG telescope
- Sodium is directed towards the observer (and Jupiter)
- Doppler shift: tens of km/s
- Highly variable within 1 night



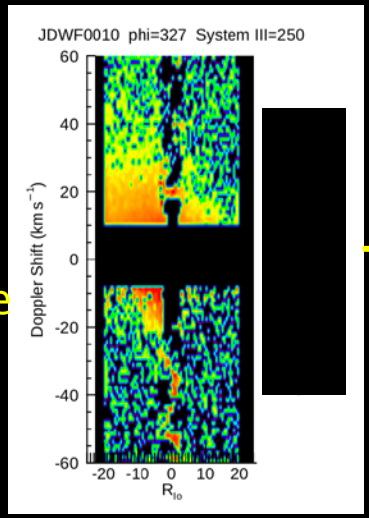
Spectra

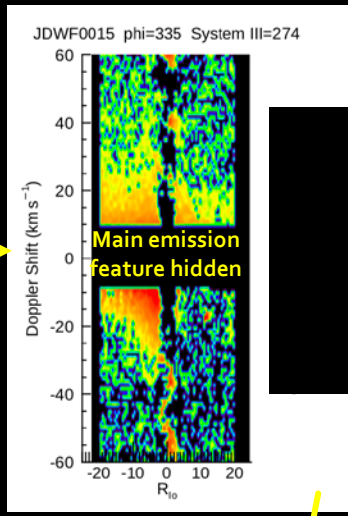
New emission feature moves from redshift to blueshift during the night

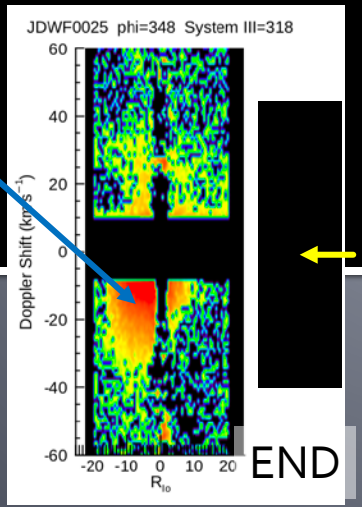


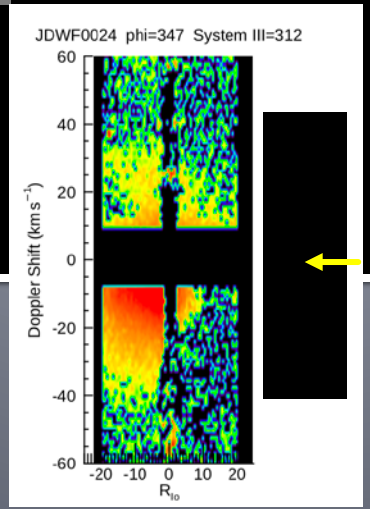


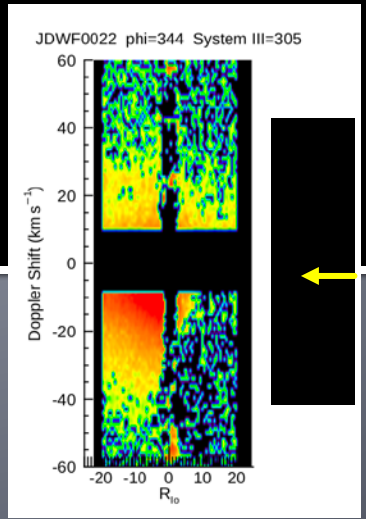
time

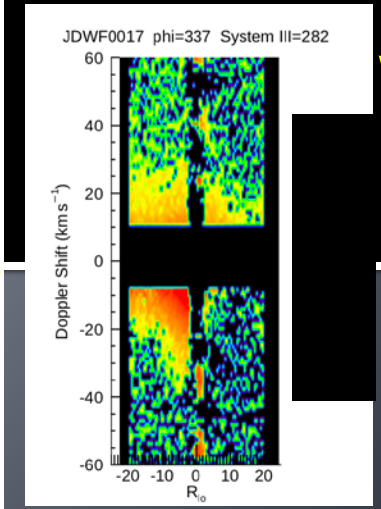












Modeling approach

Shown here is the best model (center) and what happens when we vary one of our 2 parameters keeping fixed the other one

Varying ejection location

Varying speed distribution

Jet Shifted Toward Leading Direction
68-79°, 50-90 km s^{-1}

Lower Jet Speed
45-68°, **40 km s^{-1}**

Nominal Model
45-68° W. Longitude, 50-90 km s^{-1}

Higher Jet Speed
45-68°, **130 km s^{-1}**

Jet Shifted Toward Subjovian Direction
34-45°, 50-90 km s^{-1}

Doppler Shift (km s^{-1})

Distance from Io (R_{Io})

319° 328° 337° 345°

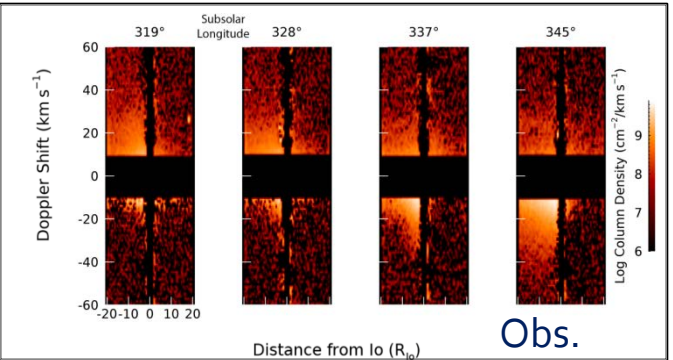
Model variables:

- Ejection location
- Speed distribution

Best model:

Atoms ejected with broad speed distribution (10-90 km/s)

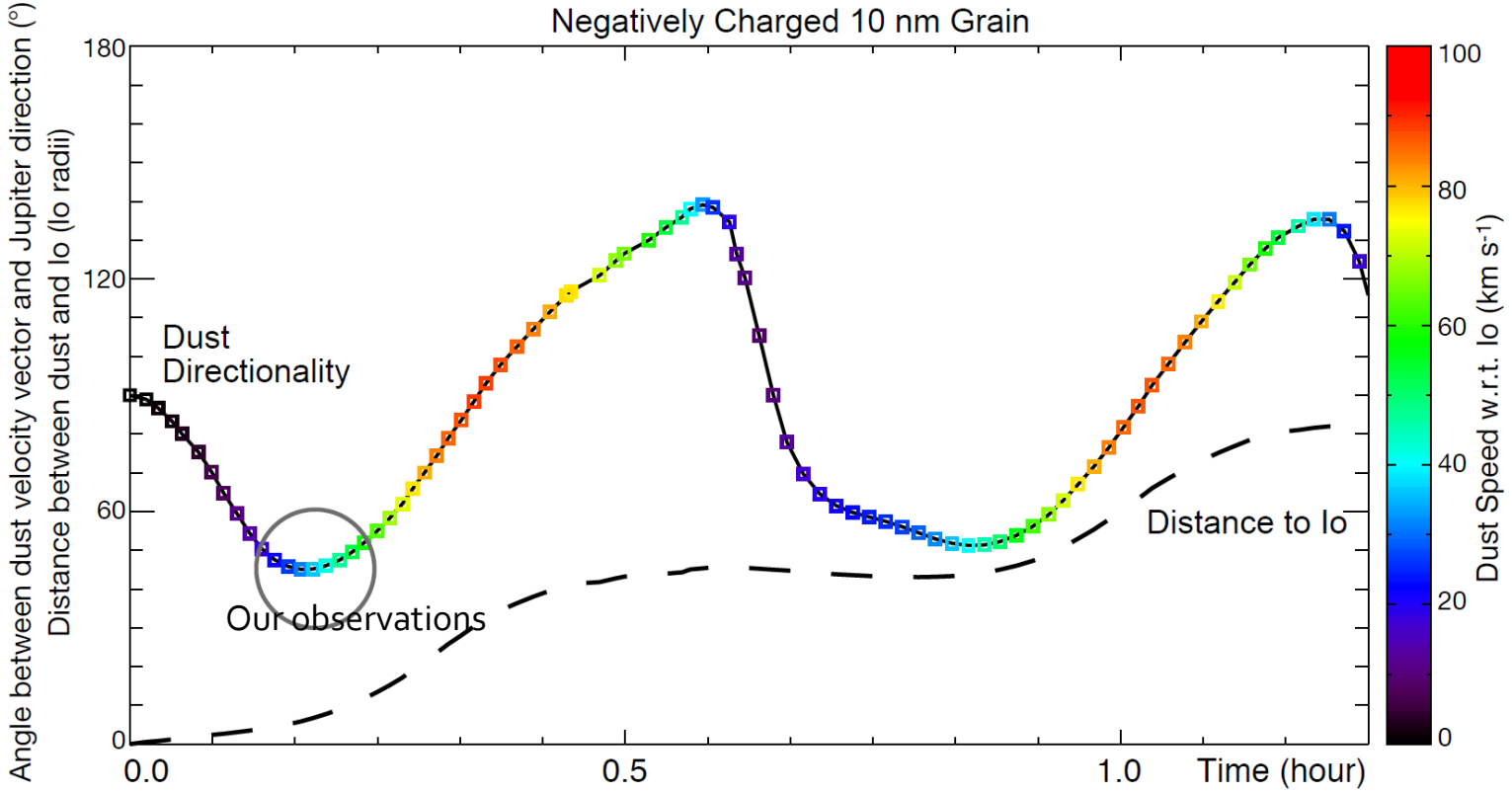
Atoms ejected in the leading/sub-Jovian hemisphere (45-70° West longitude)



Obs.

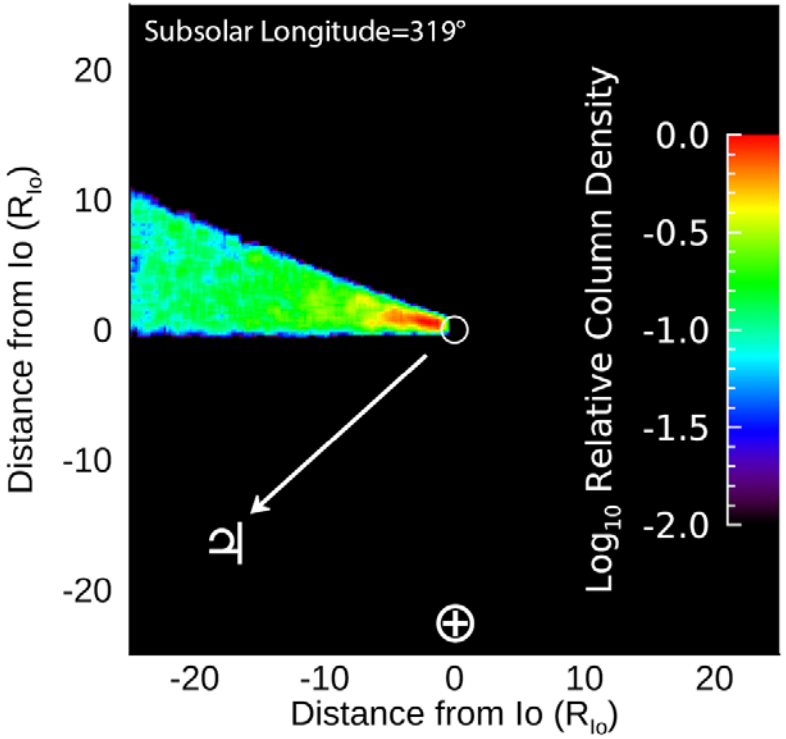
A Dust Source for our Jet

- ❑ **Trajectory necessary to explain our jet is consistent with that of negatively charged dust grains (10 nm size)**
- ❑ **Source rate of this new process: ~10^{26} s^{-1} (~10 kg s^{-1})**

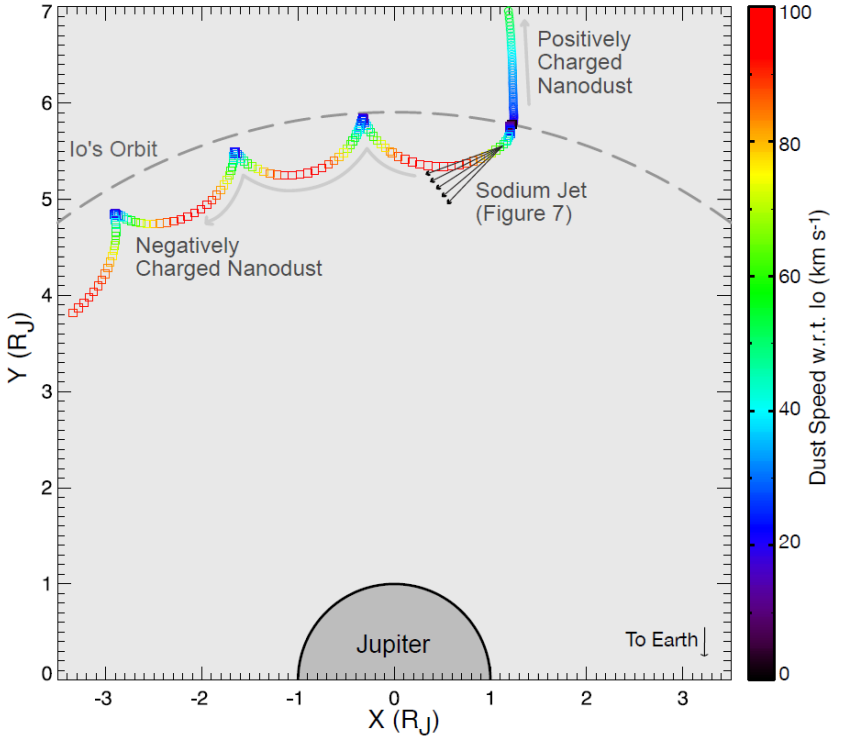


Characteristics of our "jet" are consistent with dust trajectories

Neutral sodium atoms



Negatively charged nanodust grains



Conclusions

- We have simulated a new emission feature detected in our spectra of Io's sodium Neutral Clouds
- Monte Carlo simulations of Io Neutral Clouds reveal that sodium atoms that compose our emission feature were ejected in the leading/sub-Jovian direction (45-70° West longitude) with a broad speed distribution (10-90 km/s)
- The orientation of the jet and its velocity are consistent with those of dust grains (10 nm in size) accelerated by the co-rotational electric field of Jupiter's magnetosphere.
- Rough estimate of source rate: 10^{26} Na s^{-1}, corresponding to 10 kg s^{-1}
- These observations highlight a new, albeit minor, mechanism in replenishing Io's Neutral Clouds and Io's Plasma Torus