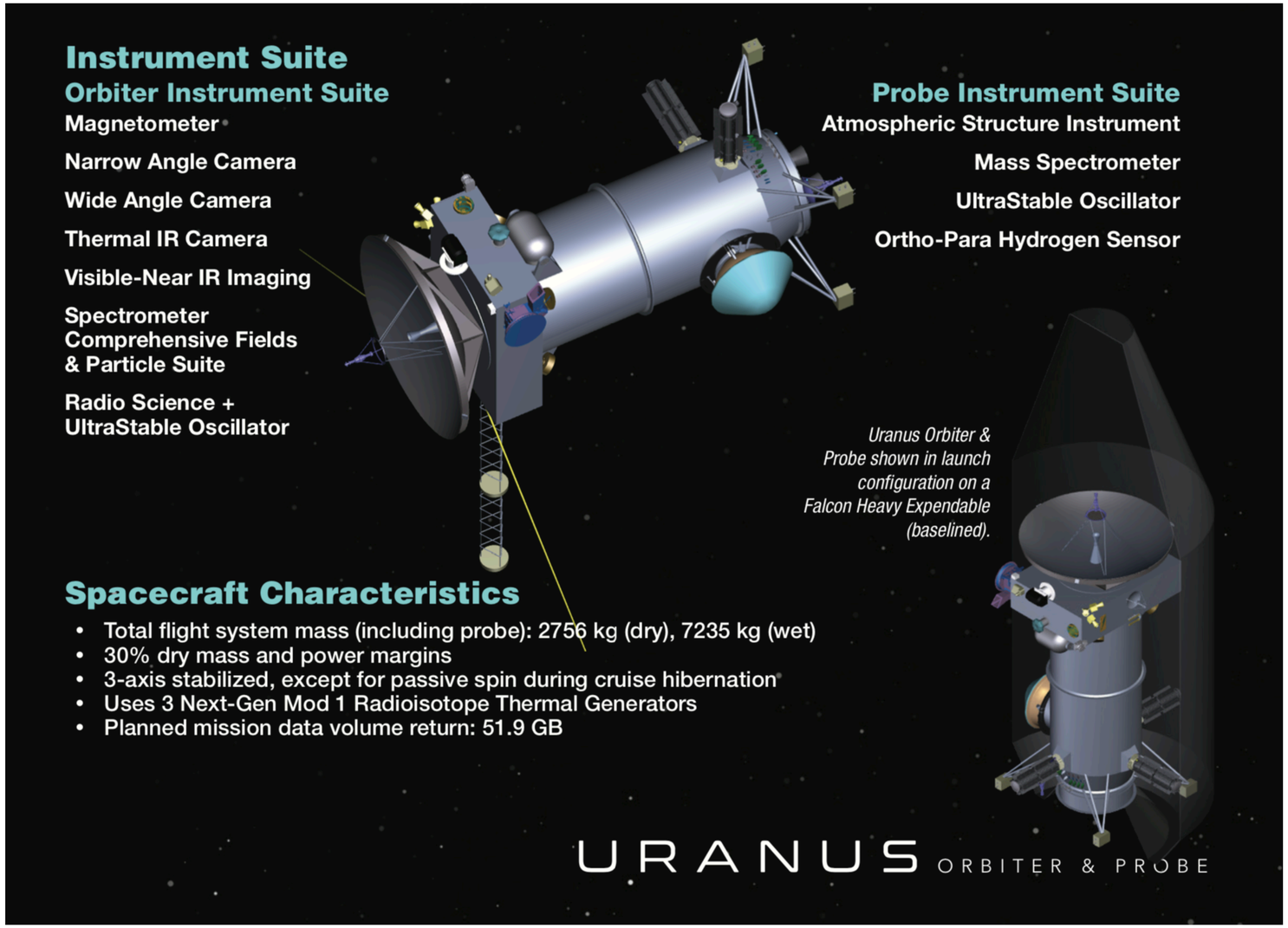
University of Zurich[UZH]

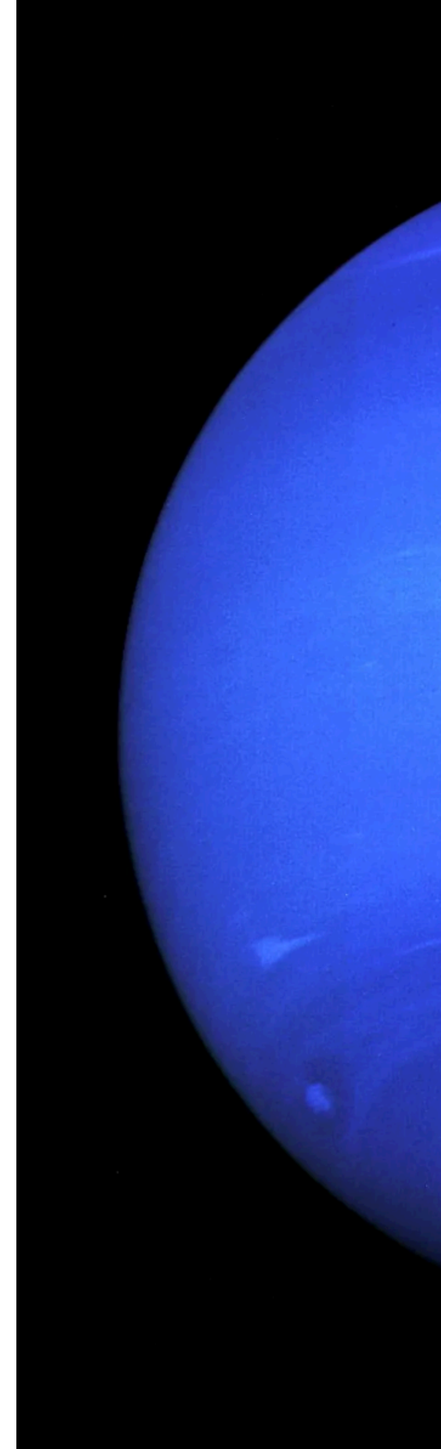
Probing Local Dark Matter with Ice Giant Missions

Lorenz Zwick, **Deniz Soyuer** & Jozef Bucko

The highest priority new Flagship mission for the decade 2023-2032 is the Uranus Orbiter and Probe mission. *(Planetary Science and Astrobiology Decadal Survey 2023 2032)*



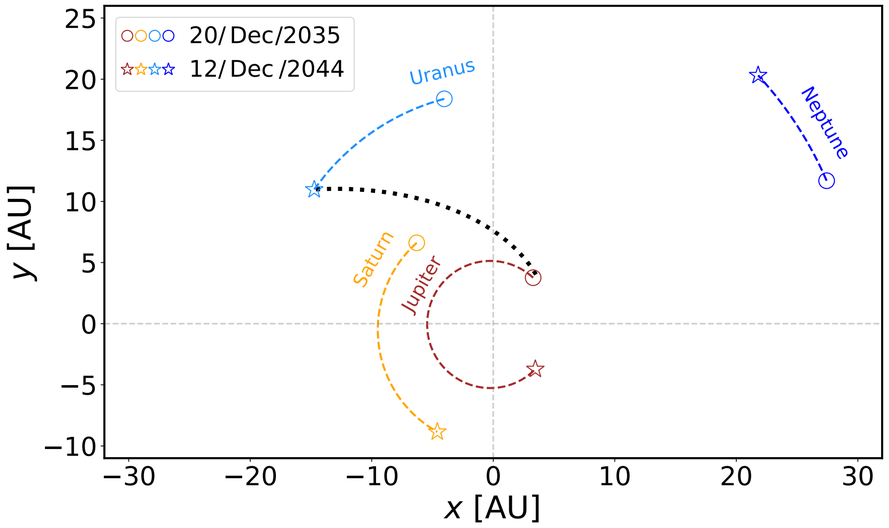
Simon et al. 2022, Journey to an Ice Giant System



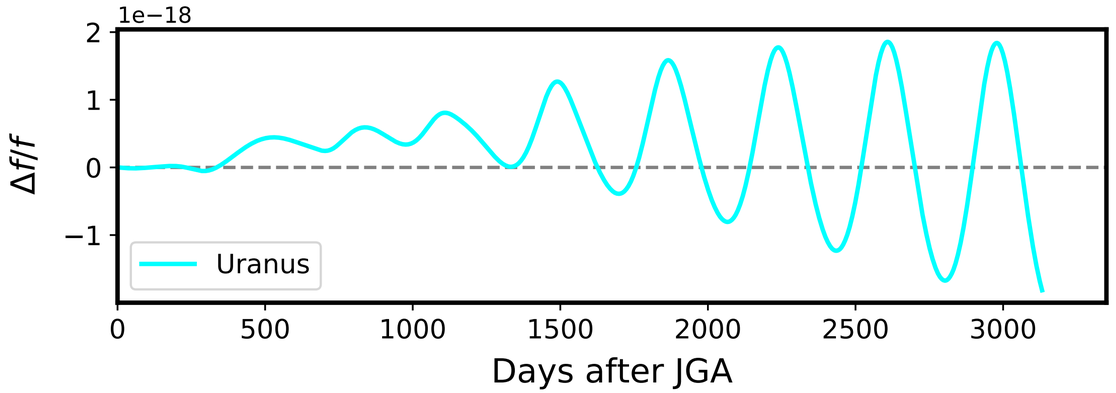
- As a spacecraft cruises interplanetary space, its motion is affected by the gravitational field of any massive object in the solar system.

- **DM** affects the trajectory by introducing a **small radial acceleration**, which in turn reduces the velocity of the spacecraft over many years of interplanetary travel.

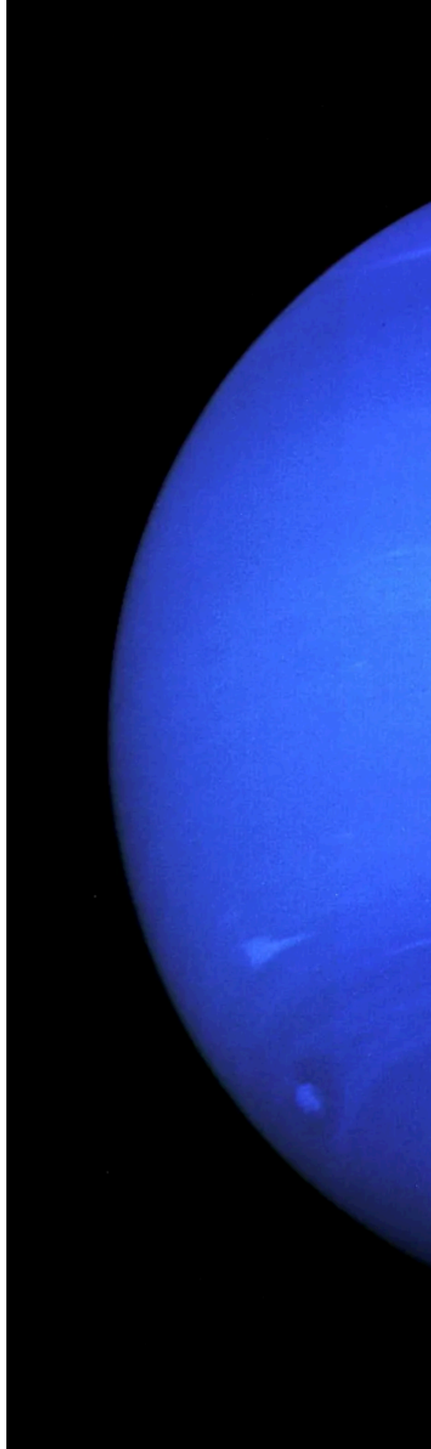
Uranus mission trajectory



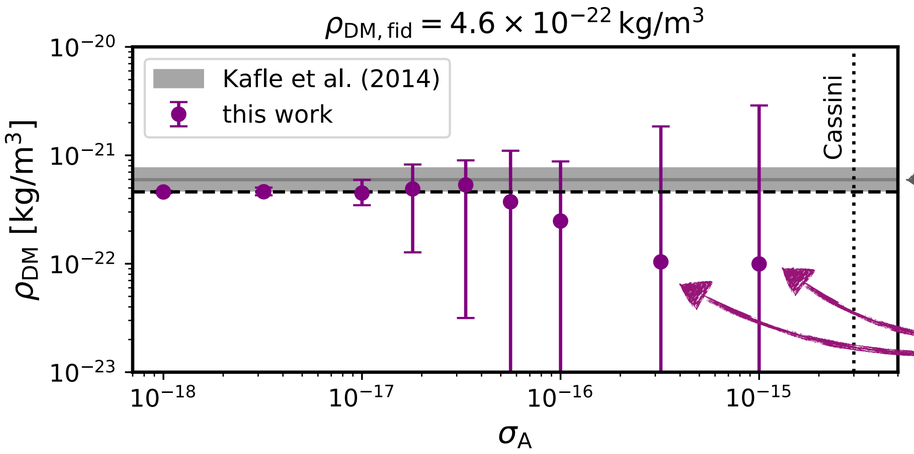
Noiseless realisation of the two way frequency fluctuation for a Uranus mission



Zwick et al. 2022, A&A

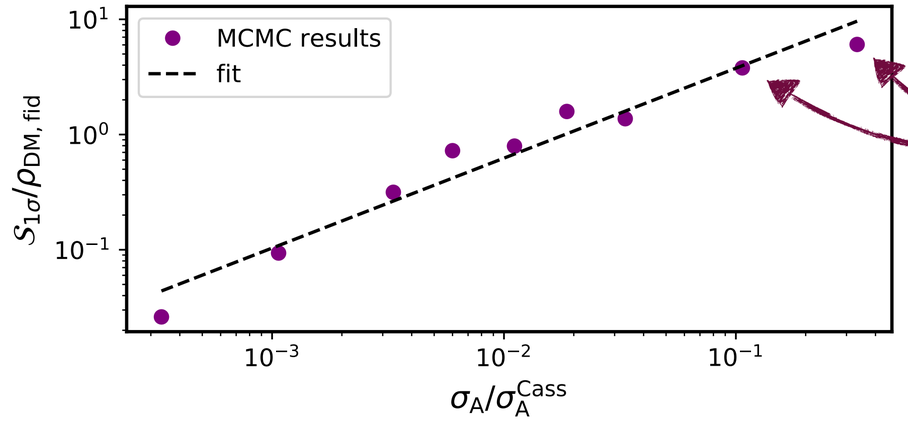


Constraints for the local DM density as a function of noise improvement
(relative to Cassini)



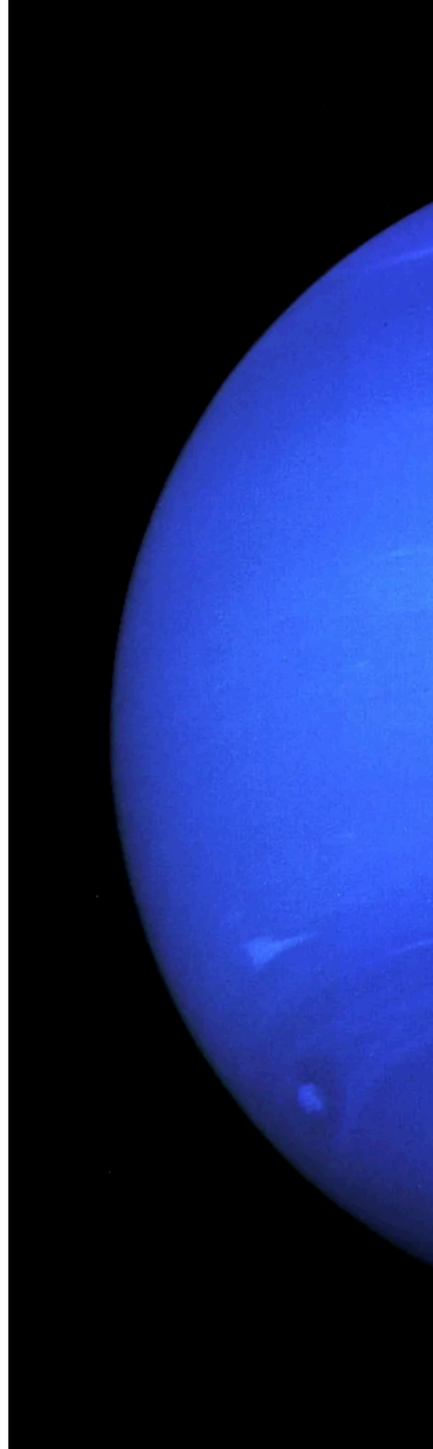
Galactic DM density estimates

Ability to recover galactic level DM densities as a function of noise improvement



Uncertainty as a function of noise improvement

Noise improvement relative to Cassini-era **Allan Deviation**
(frequency averaged stability of the Doppler link)



Zwick et al. 2022, A&A

Tracking a spacecraft's trajectory is **not the only way** to probe the local dark sector!

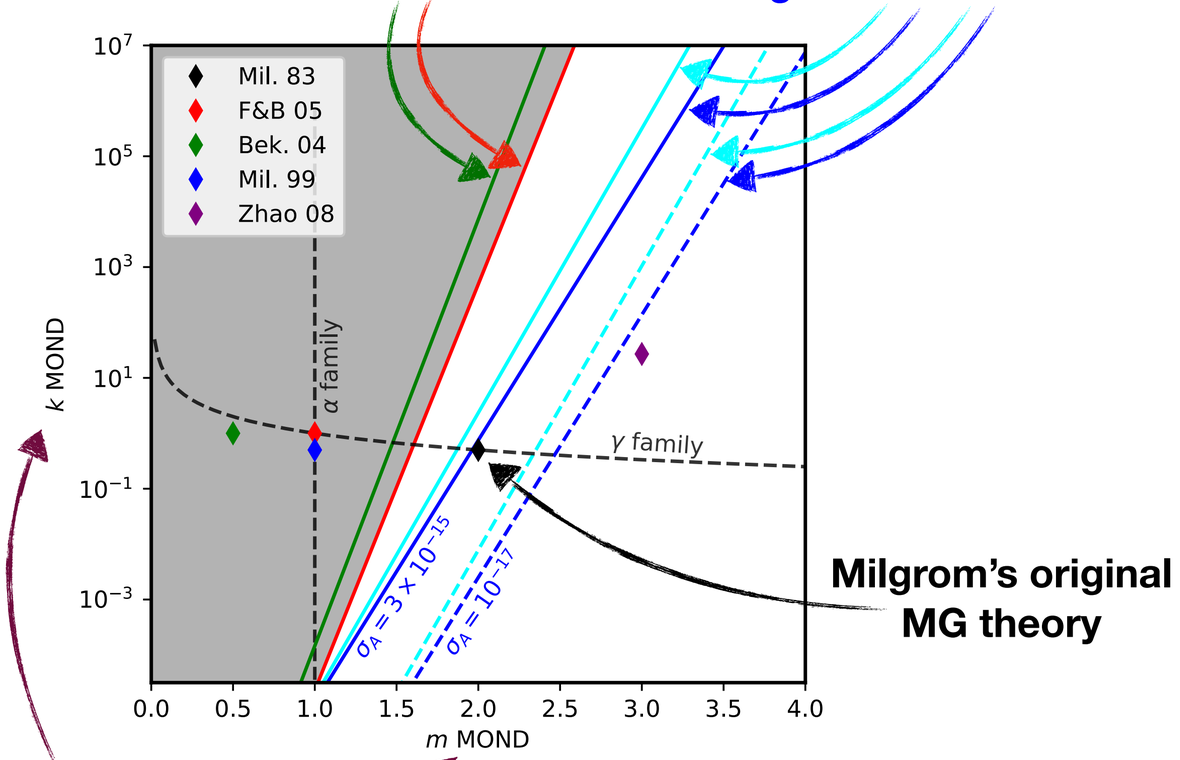
More mass inside planet's orbits causes the perihelion of planets to precess more!

Orbiters would constrain the extra-precession of ice giants…

…Ruling out modified gravity theories!

Constraints by Earth and Mars

Constraints by ice giants missions



Milgrom's original MG theory

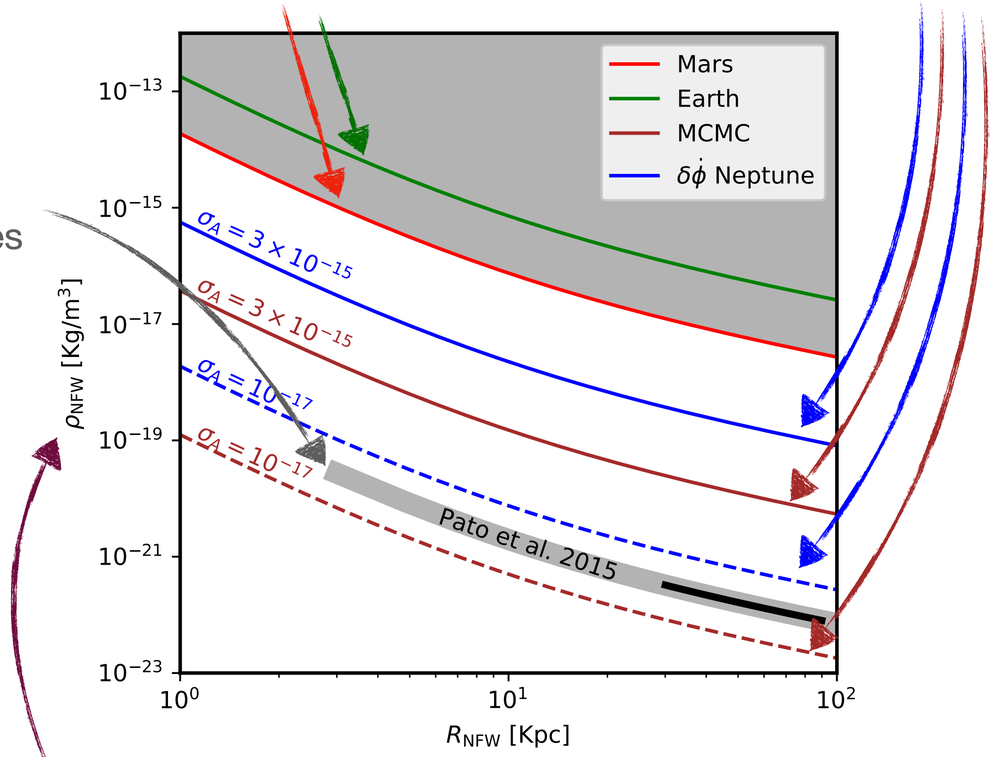
MG parameters

…Constraining dark matter profiles!

Constraints by Earth and Mars

Constraints by ice giants missions

Galactic DM density estimates



Galactic DM halo parameters

Zwick et al. 2022, A&A

Takeaway

Zwick et al. 2022

Ice giant missions…

- could **constrain the dark matter density** in the solar system,
- **rule out** various modified gravity scenarios.

Challenges:

- Convincing people to actually send a mission. ✓
- Accurately modelling the objects in the solar system and their effects on trajectories.
- Improving the various noise sources on the Doppler link.