Measurements of pulsar accelerations reveal Milky Way's dark side

Sukanya Chakrabarti (IAS, IBM Einstein Fellow, RIT)
Philip Chang (University of Wisconsin-Milwaukee)
Michael Lam (RIT/Nanograv)
Sarah Vigeland (University of Wisconsin-Milwaukee/Nanograv)
Alice Quillen (University of Rochester)

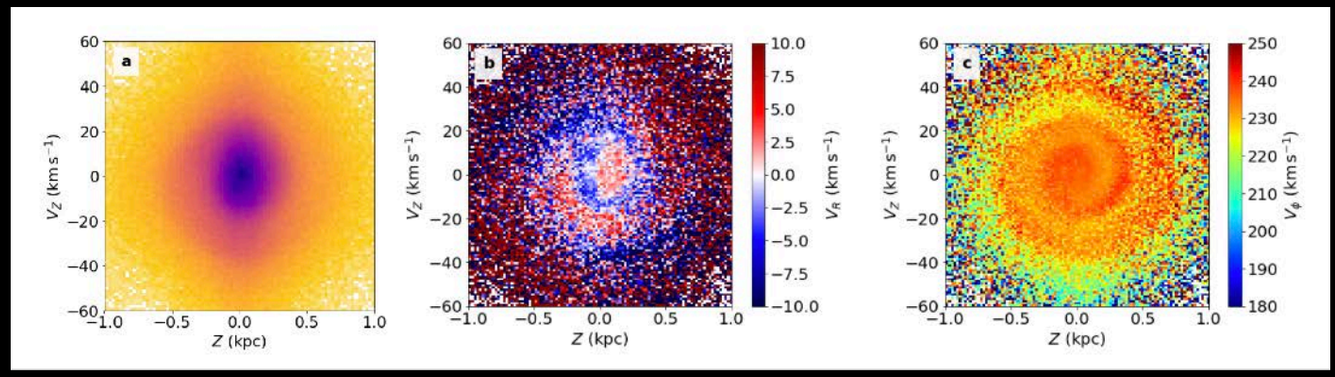
Email: chakrabarti@astro.rit.edu
chakrabarti@ias.edu

Motivations

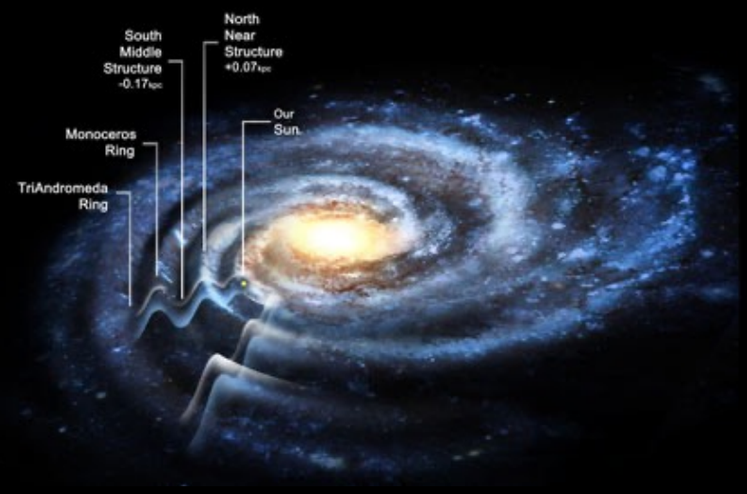
Why direct measurements of the Galactic acceleration?

Traditional method: *estimate* accelerations. True acceleration in interacting Galaxy may be different

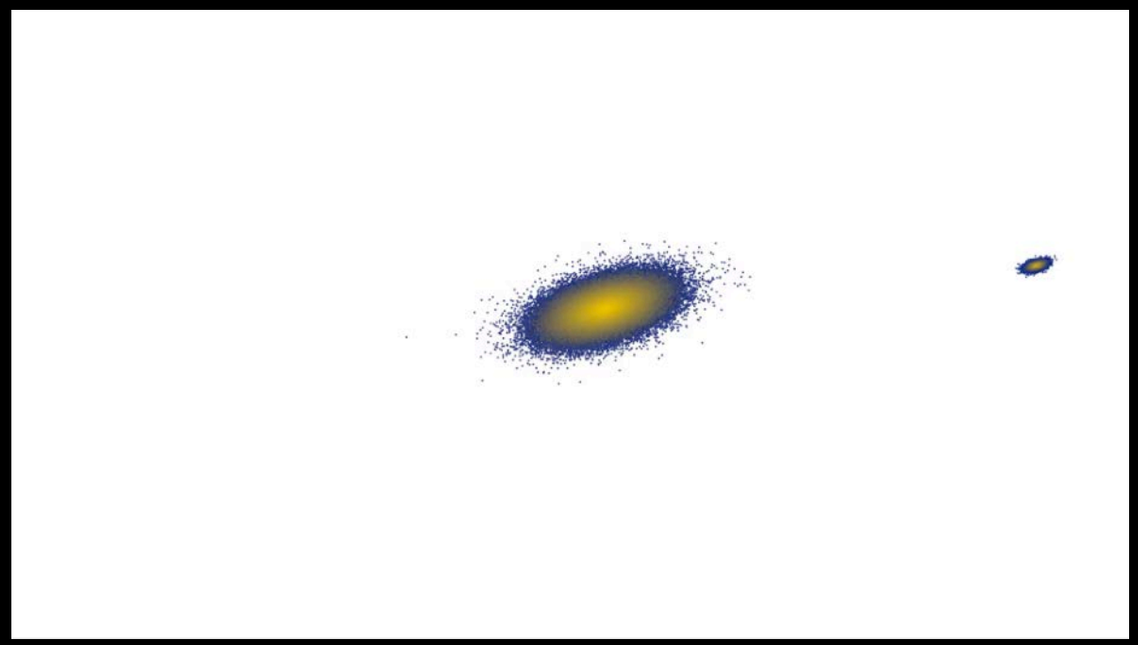
1. High precision measurements of change in velocity (Chakrabarti et al. 2020)
2. Pulsar timing (Chakrabarti et al. 2021, accepted to ApJ Letters)



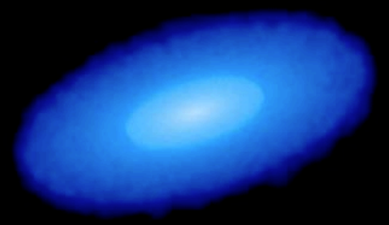
Antoja et al. 2018



Xu et al. 2015

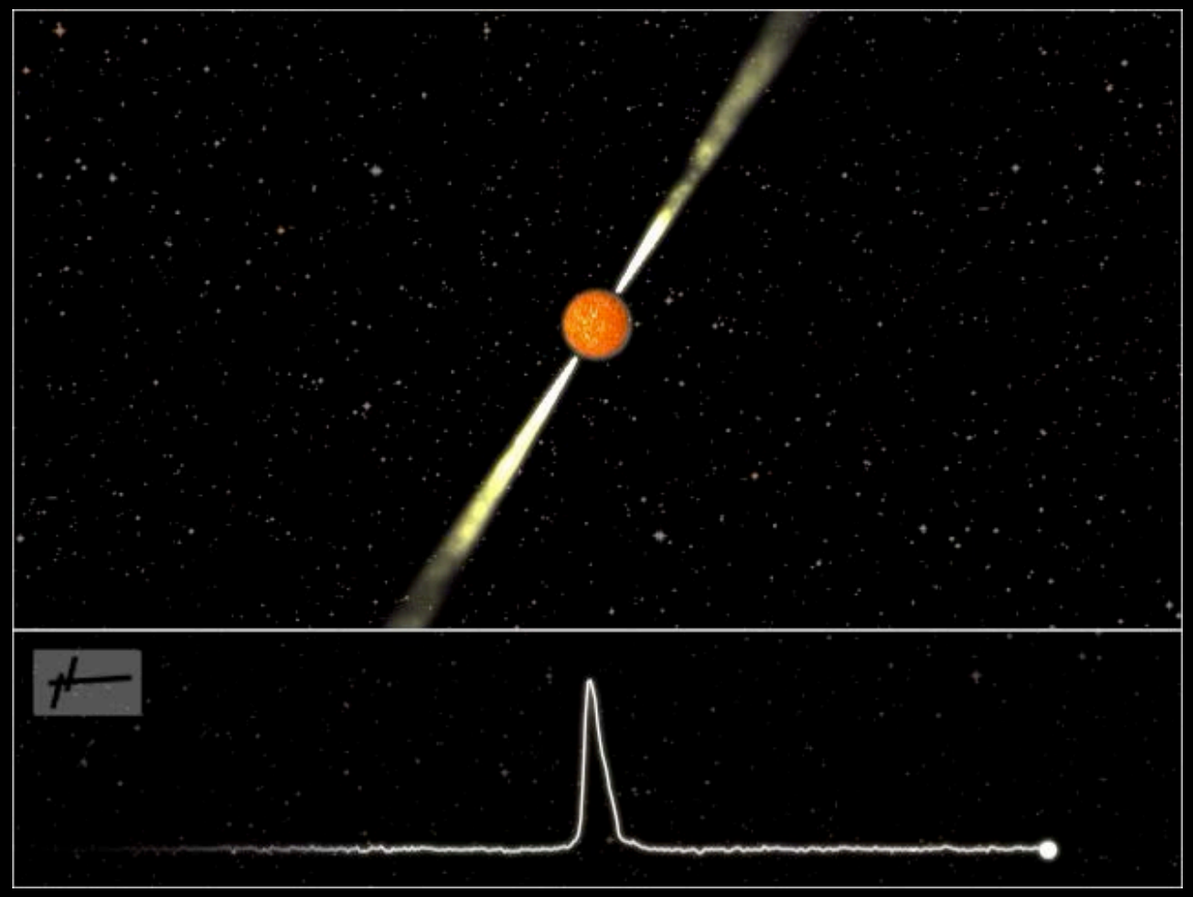


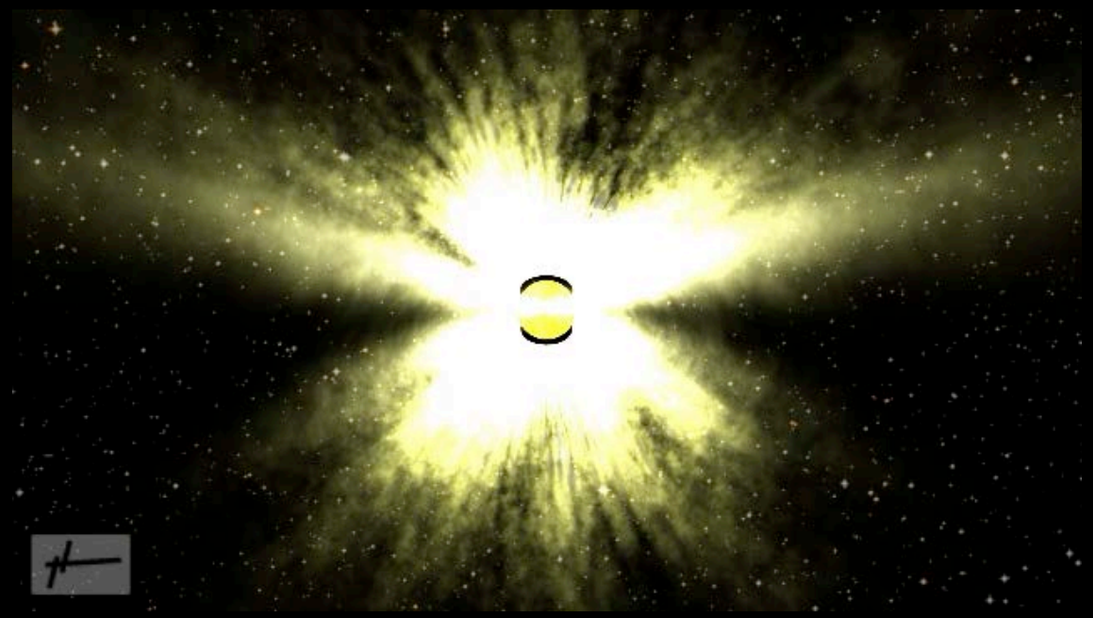
Milky Way interaction with Antlia2 : Chakrabarti et al 2019



Galactic acceleration from pulsar timing

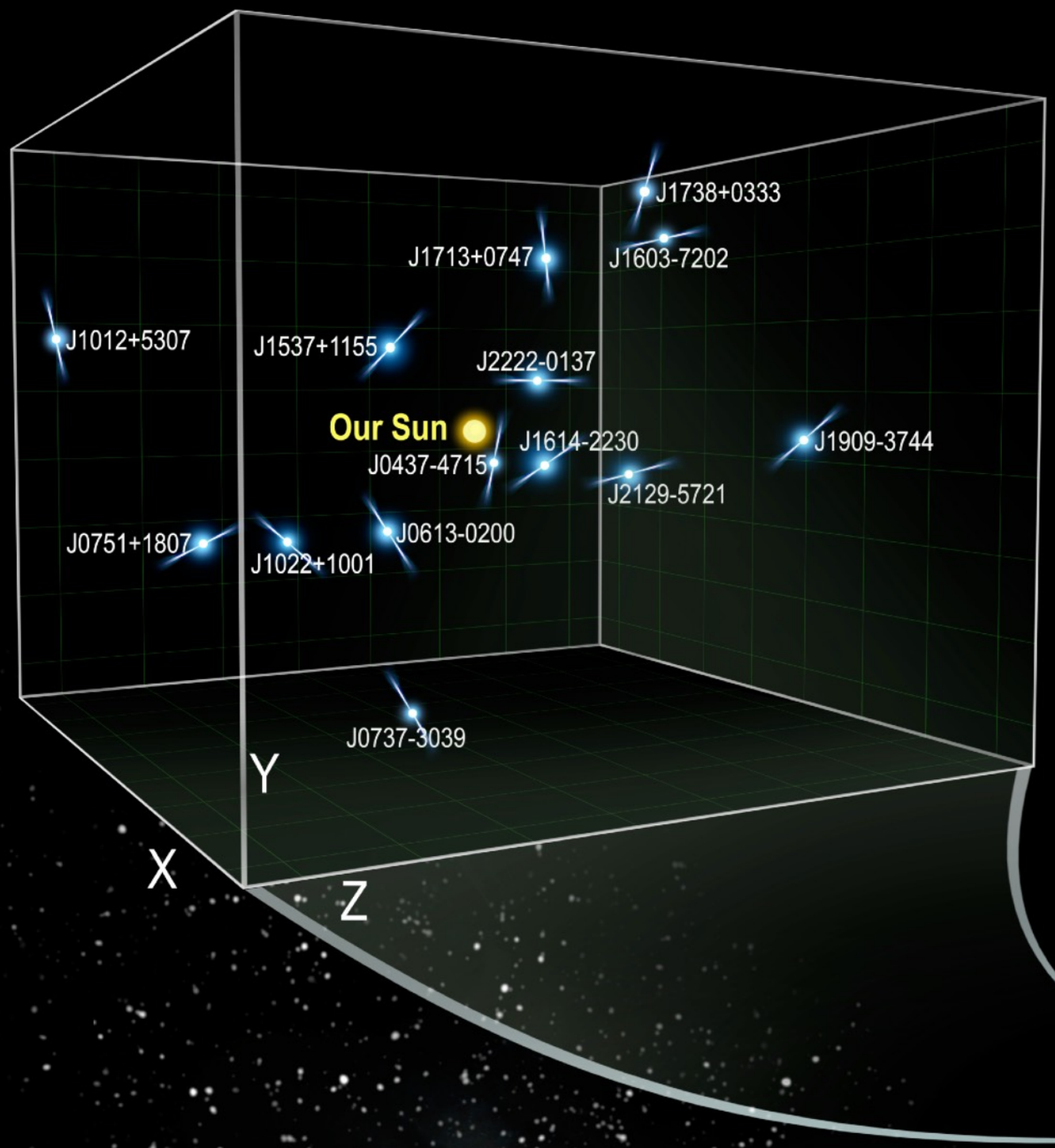
- Temporal stability of pulsars rivals atomic clocks
- Binary millisecond pulsars & change in *orbital* period: Galactic accelerometers.





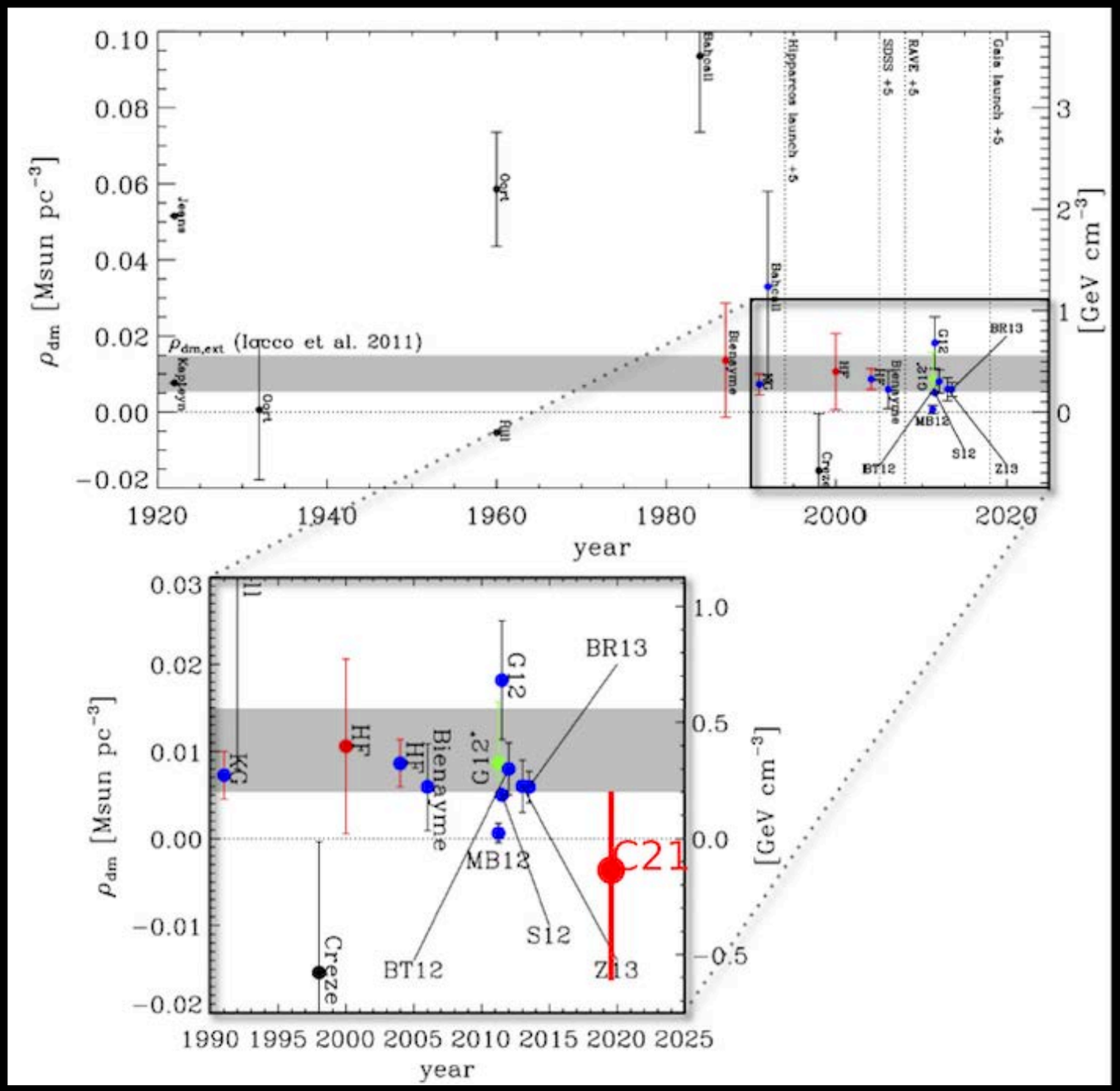
Credit: "Joeri van Leeuwen"

Using binary millisecond pulsars to measure Galactic accelerations



Credit: IAS; Dana Berry

Galactic parameters from pulsar timing



Our (C21) value over-plotted with earlier values from Read (2014)

<u>These parameters affect direct detection experiments for dark matter!</u>

Oort limit (Galactic mid-plane density)

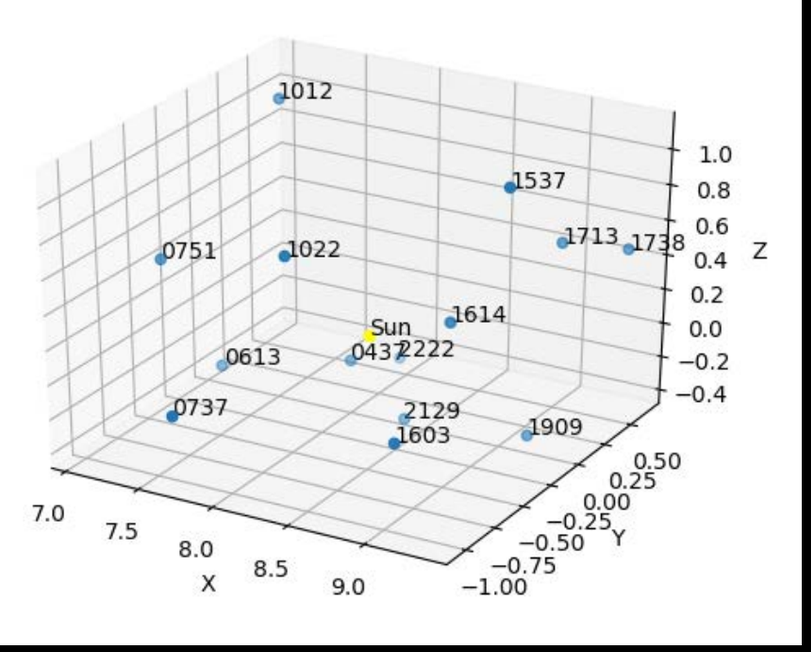
$$0.08^{0.05}_{-0.02} M_\odot/\mathrm{pc}^3$$

Subtracting baryon (visible matter) density :

$$\rho_{DM} = -0.004^{0.05}_{-0.02} M_\odot/\mathrm{pc}^3$$

- Oblateness traces disk
- slope of rotation curve: -5^{6}_{-8} km/s/kpc

~ 0.01 M_{sun}/pc^3 ~ $7x10^{-25}$ g/cm^3 : 740 g of dark matter within earth (~ 10^6 kg gold produced every year)



Summary & Future

- First determination of Galactic parameters from acceleration measurements, which can inform direct detection experiments for dark matter:

1. Mid-plane density and dark matter density close to but lower than modern estimates
2. Oblateness of Galactic potential traced by pulsars similar to disk (rather than halo)
3. Large uncertainties in slope of rotation curve (but consistent with being flat)

- Combination of high precision radial velocity measurements and pulsar timing: dark matter sub-structure

email: chakrabarti@astro.rit.edu
chakrabarti@ias.edu
Twitter: sukanya_X

RESEARCH CORPORATION *for* SCIENCE ADVANCEMENT