Dark matter, GWs and compact objects

Science Fair 2026

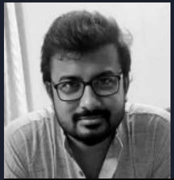
Sayak Datta

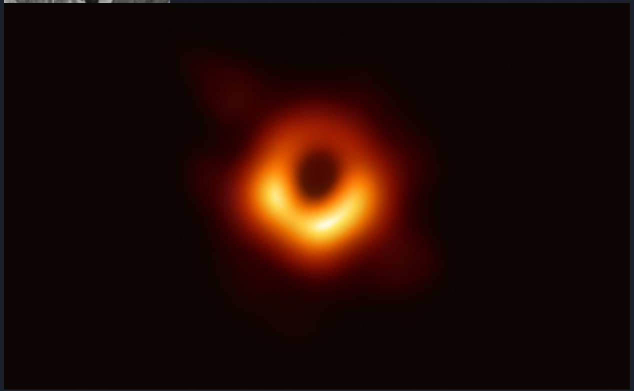


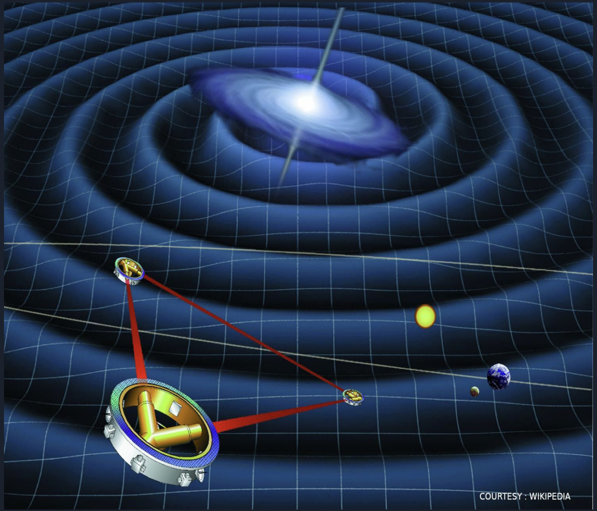


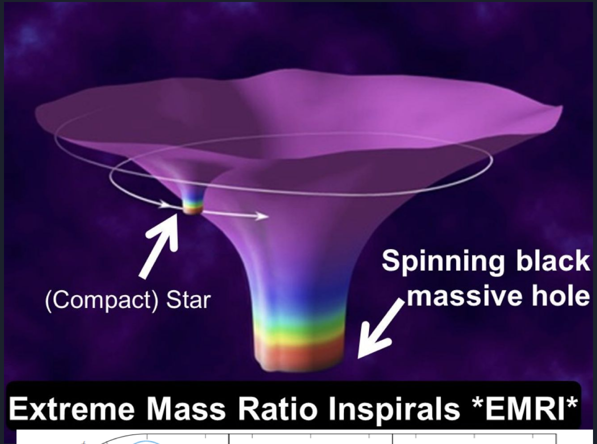

Extreme Mass-Ratio Inspirals (EMRI)

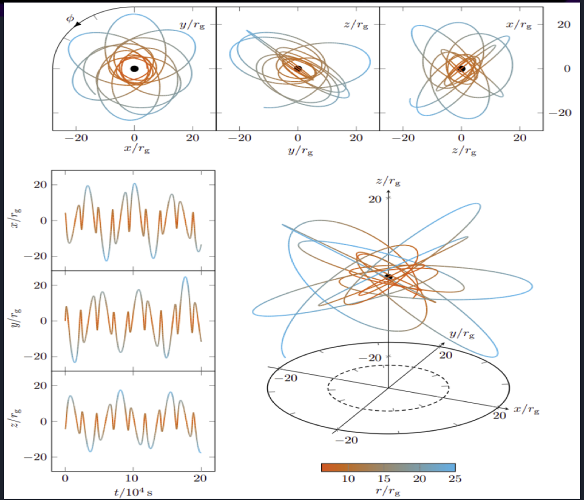
- ❑ Supermassive BH+stellar object
- ❑ BHs are not alone
- ❑ Dark Matter Halo, accretion etc
- ❑ Environment affects EMRI?



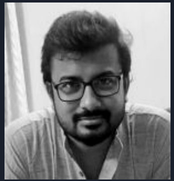




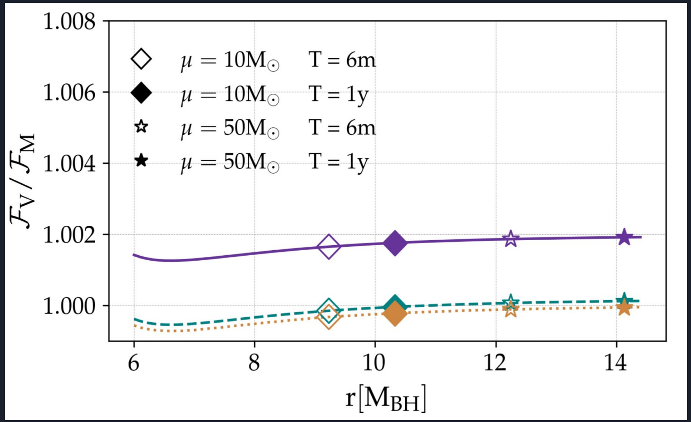




Formalism for environment in EMRIs



- ❑ Identify it's strength
- ❑ Add it on BH
- ❑ Compute EMRI
- ❑ Non-rotating DONE!!!
- ❑ Is it spinning?



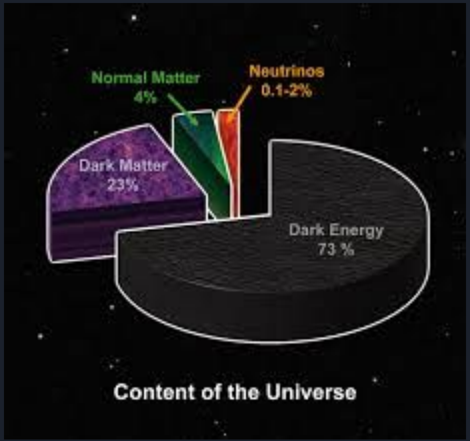
Formalism for environment in EMRIs

- ❑ Is that all?

Formalism for environment in EMRIs

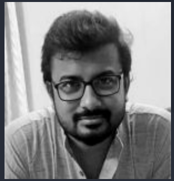
- Is that all?

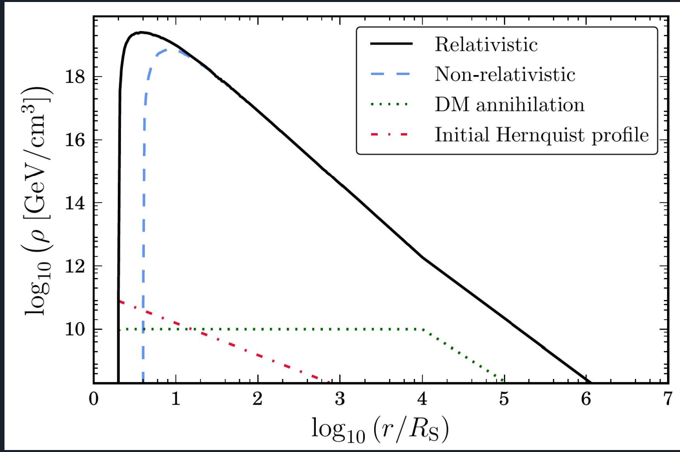
- Halo rotation
- Halo structure
- Dark matter Accretion
- Baryonic matter accretion
- Hot environment
- Viscosity
- Dynamical friction
- Migration
- Compact object properties
- Anisotropy?
- All important?
- Who knows!

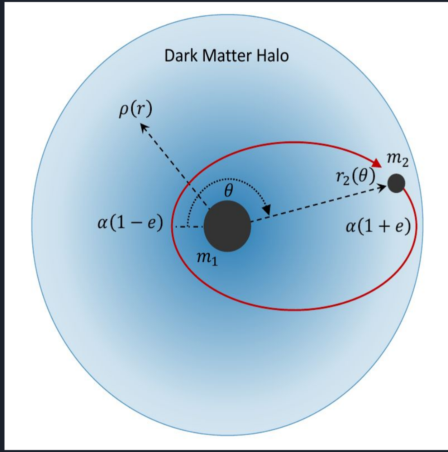


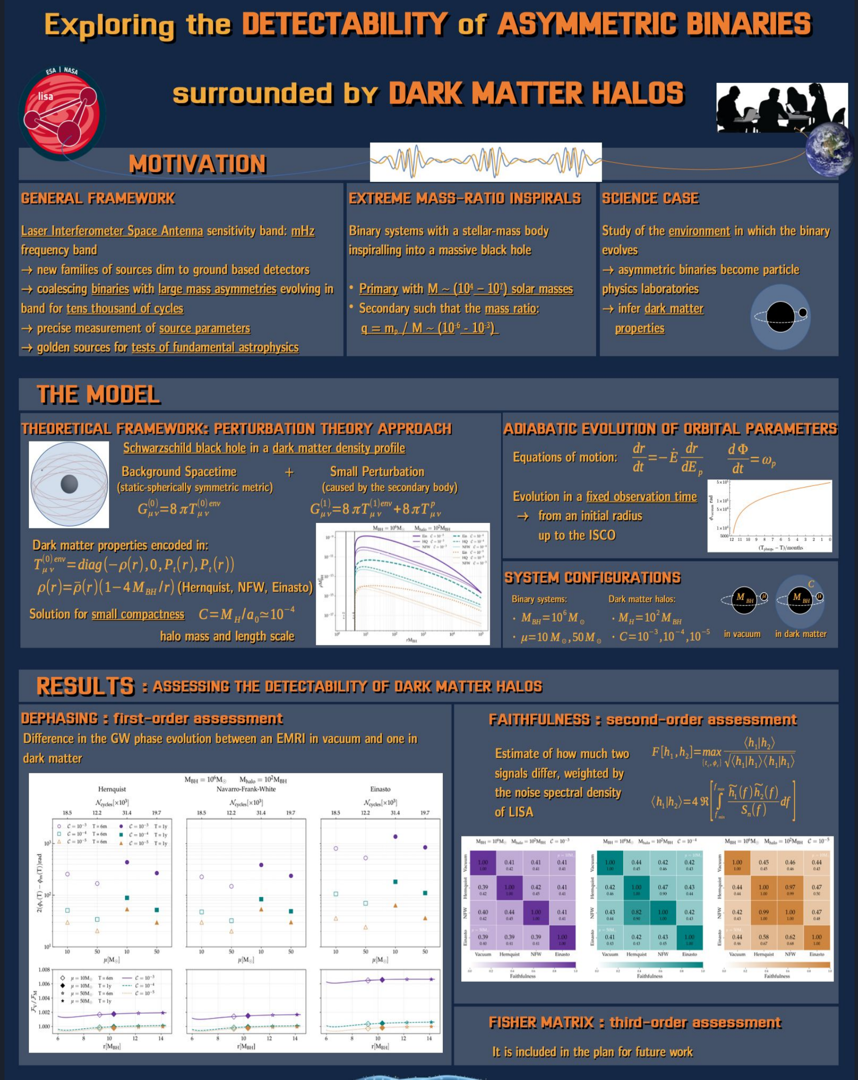
Dark matter spikes

- ❑ DM forms "spikes" near BH
- ❑ Affects GW?
- ❑ QNM?

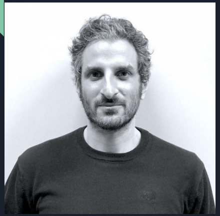


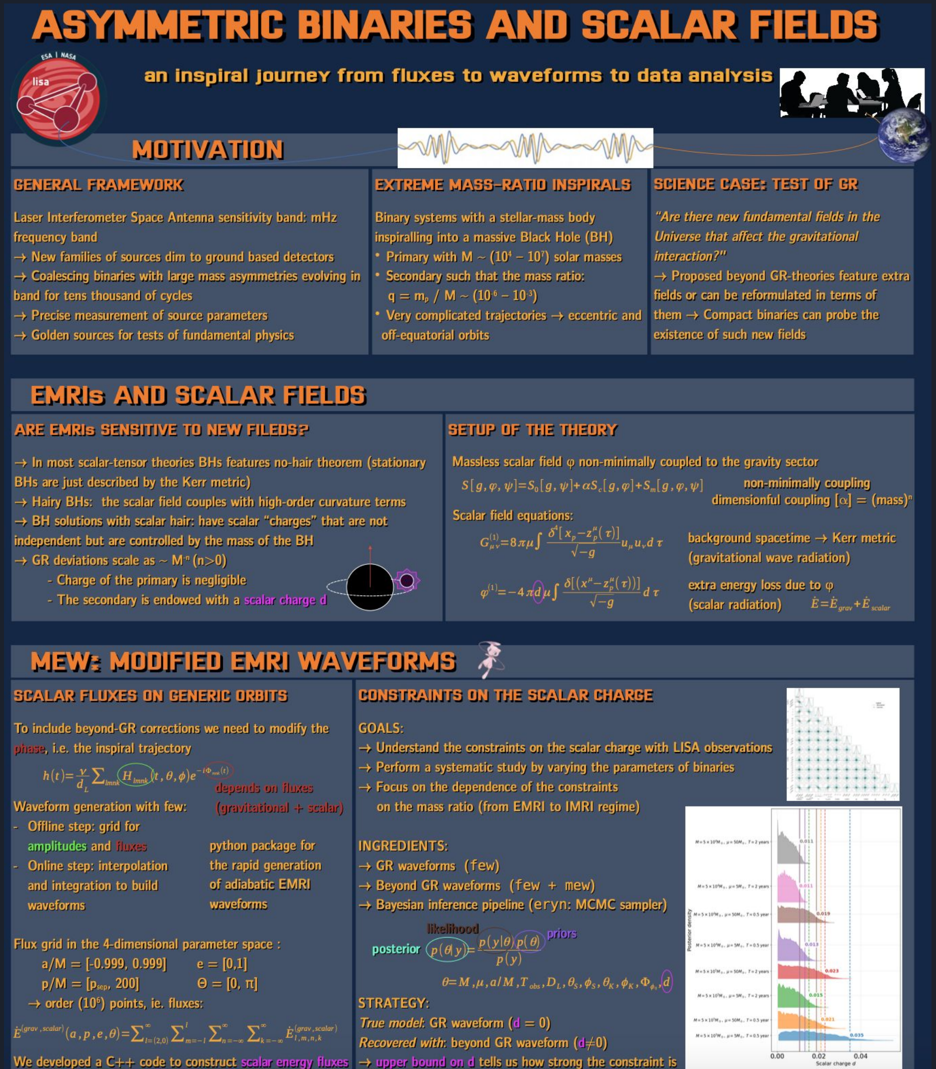






See Sara's poster!





See
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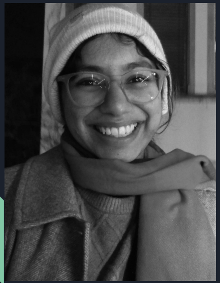
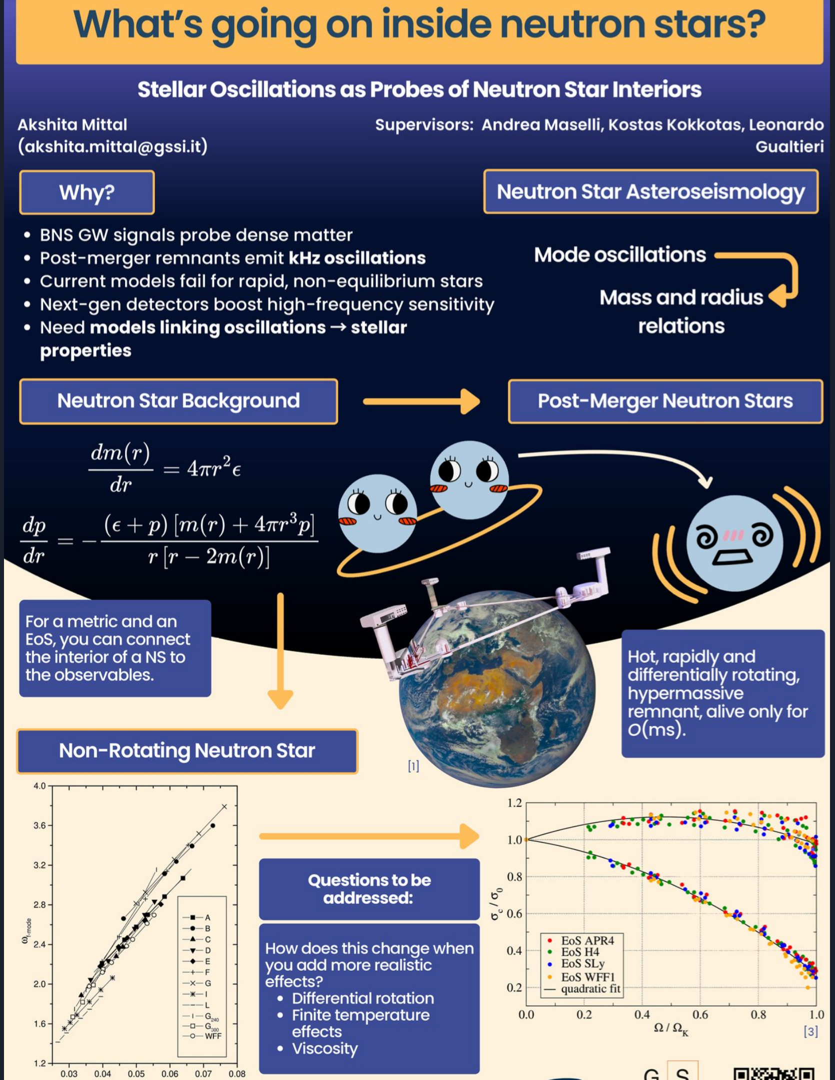
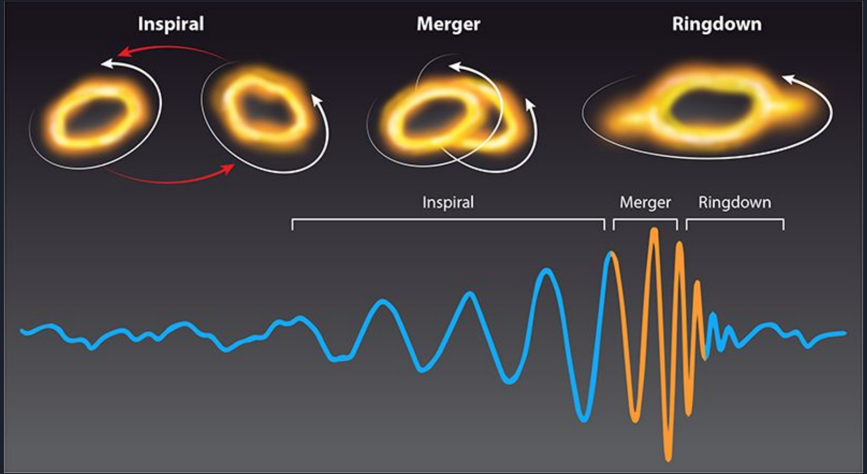




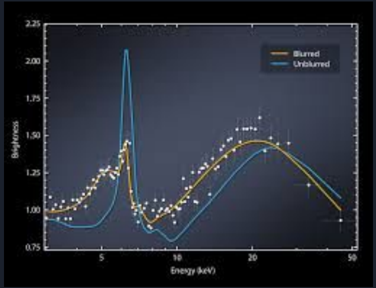
See Akshita's poster!

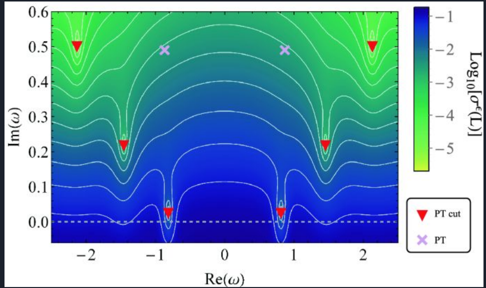
Asymmetric mass binaries and BH spectroscopy

- ❑ Ringdown phase for BH systems with mass asymmetry
- ❑ GW signals from orbital configurations.



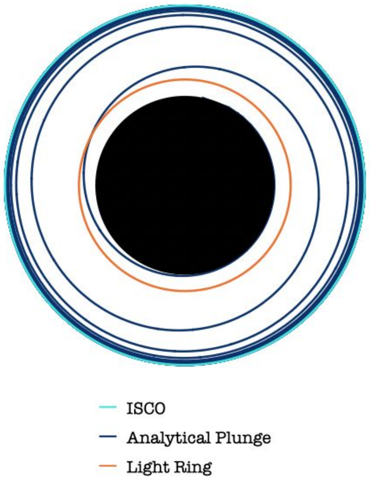
- ❑ Spectroscopy to find BH QNMs, in matter halos.



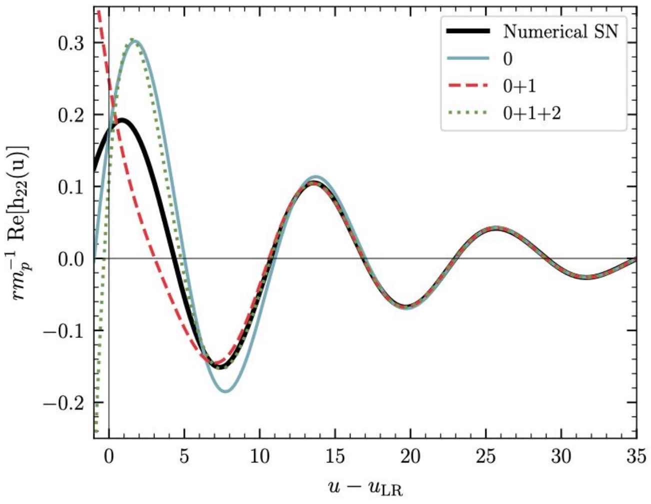


Probing ringdown physics in asymmetric black hole mergers

From plunge dynamics…

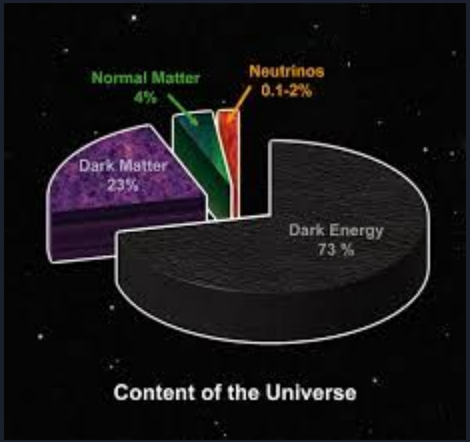


M. Della Rocca, LP + (2025)



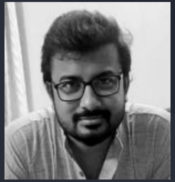
Using the right description for the **plunge** of the secondary in **asymmetric binaries** in **frequency domain**

Reconstructing the amplitude of the **ringdown** signal for a circular, equatorial plunge in terms of **excitation coefficients**

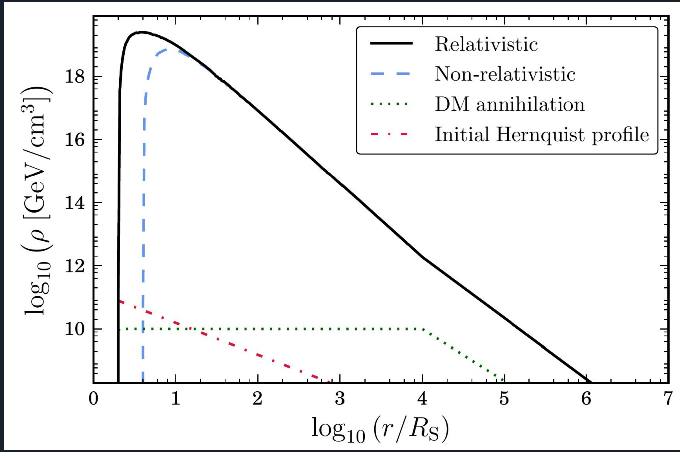


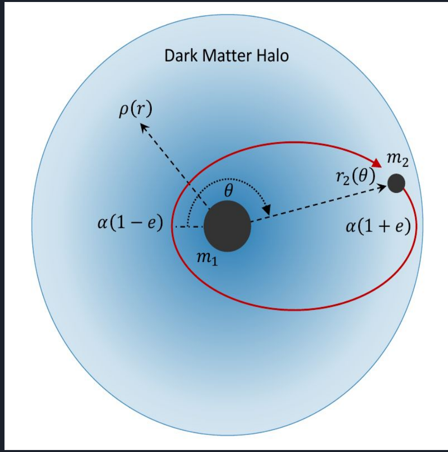
Perturbation and QNM





- ❑ How EMRI injects energy into medium?
- ❑ Affects GW?
- ❑ QNM?





Course: GC5 - Sayak Datta

- What are Neutron stars?
- What makes them?
- How do they respond in tide?
- Does LIGO see them?
- What GW tells about them?
- How?
- What is in the future?