

```
/* So, what would you say  
you do here? */
```

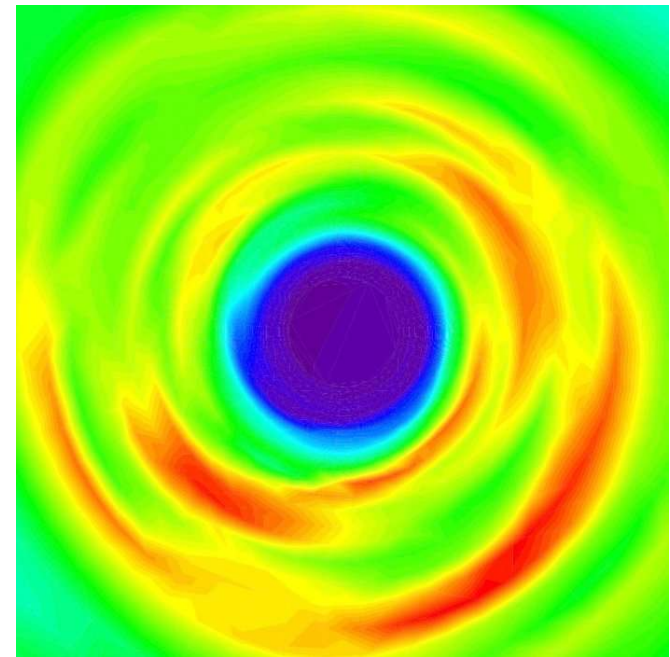
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UC Santa Barbara

```
void OUTLINE() {  
    MHD inner torus >>  
        hydrodynamic simulations;  
    Analysis Tools >>  
        Simulation QPOs;  
    Torus initialization &&  
        Current Simulations;  
}
```

# /\* A Brief History \*/

- Full **MHD**, black hole accretion simulations show the growth of an **inner torus** with structure!
- Inner torus dynamics might exhibit active **PPI**.
- Hydro simulations can provide **quantitative** evidence.



20M

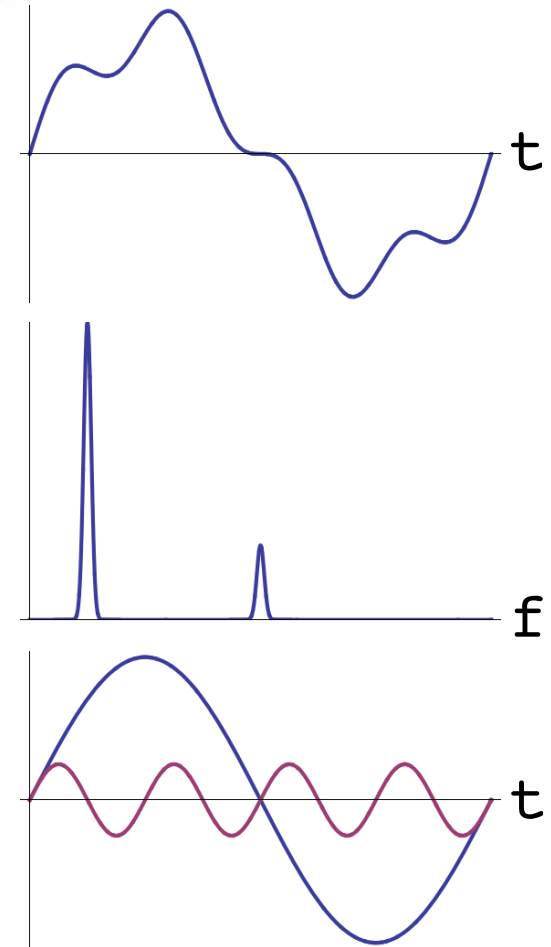
# /\* Analysis Tools: Time Domain Dynamics \*/

- A **Power Spectrum** describes “how much” of a signal is oscillating between the frequencies **f** and **f+df**.

- We define **Power** as:

$$P_h(f) = \left| \int_{-\infty}^{\infty} h(t)e^{2\pi ift} dt \right|^2 + \left| \int_{-\infty}^{\infty} h(t)e^{-2\pi ift} dt \right|^2$$

- Windowing, Binning, & Partitioning(?)



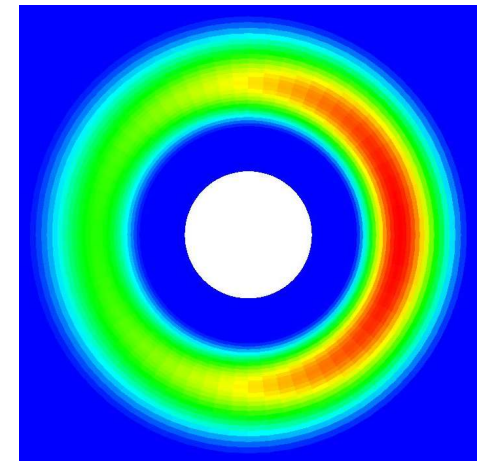
# /\* Analysis Tools: Spatial Structure \*/

- To better **identify** a structure, we use **mode projections**, i.e.

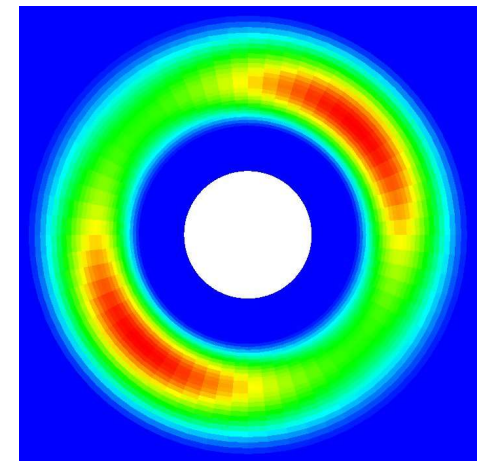
$$C_m(t) = 2 \int_0^{2\pi} h(t, \phi) \cos(m\phi) d\phi$$

$$S_m(t) = 2 \int_0^{2\pi} h(t, \phi) \sin(m\phi) d\phi$$

- The **PS** of **C** and **S** relates specific frequencies with given modes and helps **connect** data with theory.

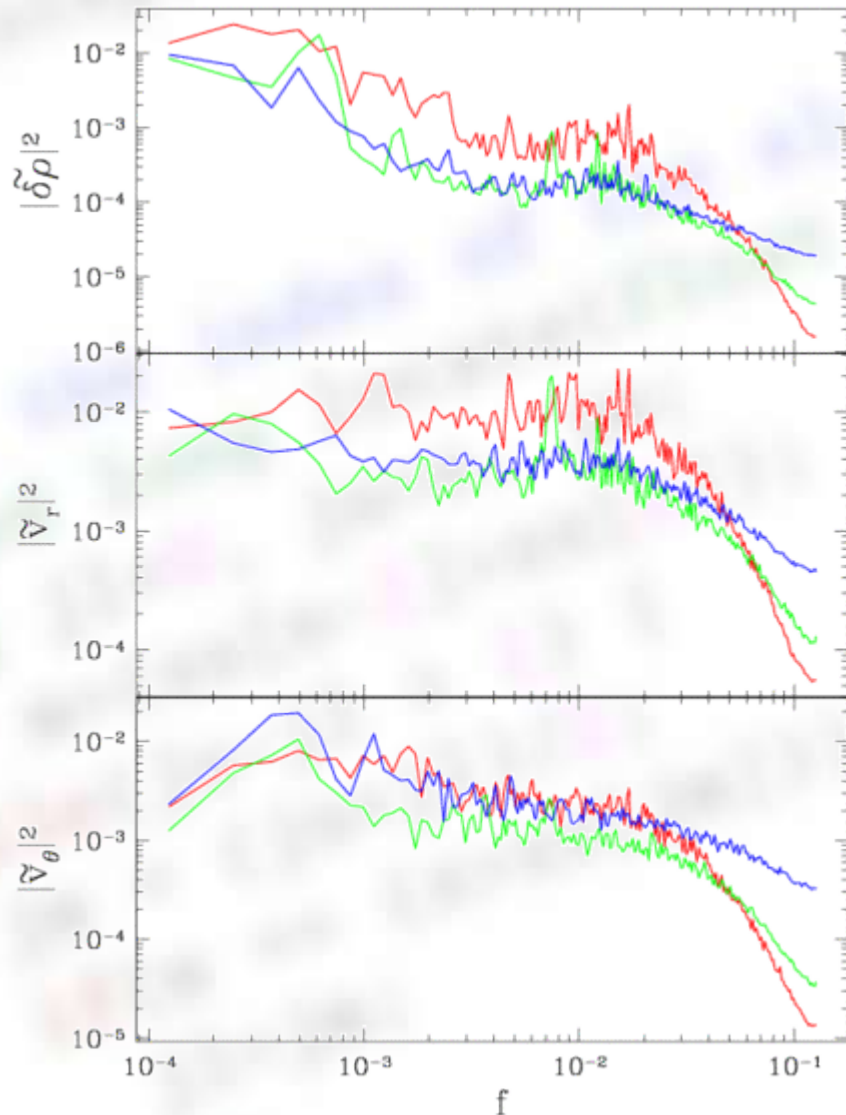


$C_1 > 0$

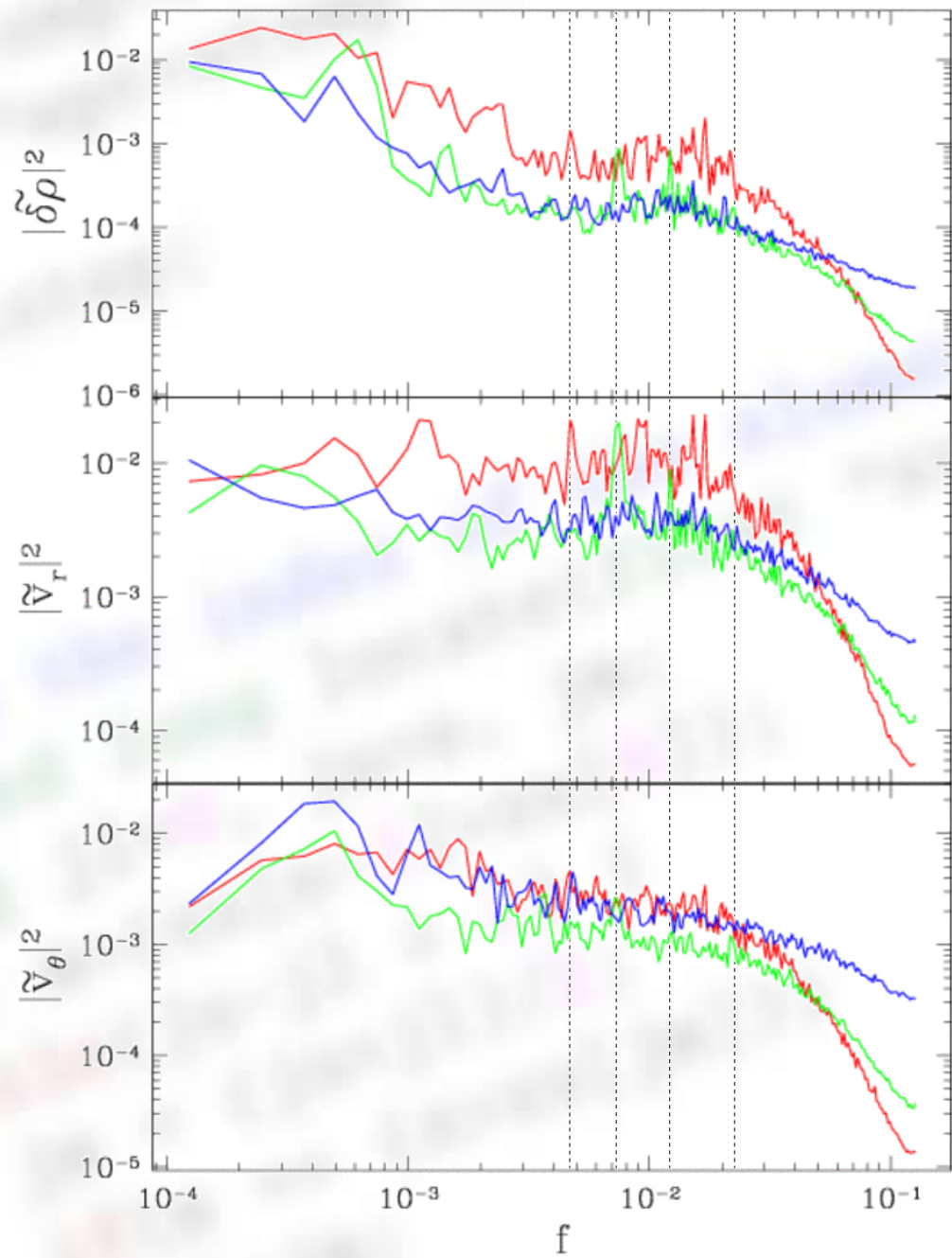


$S_2 > 0$

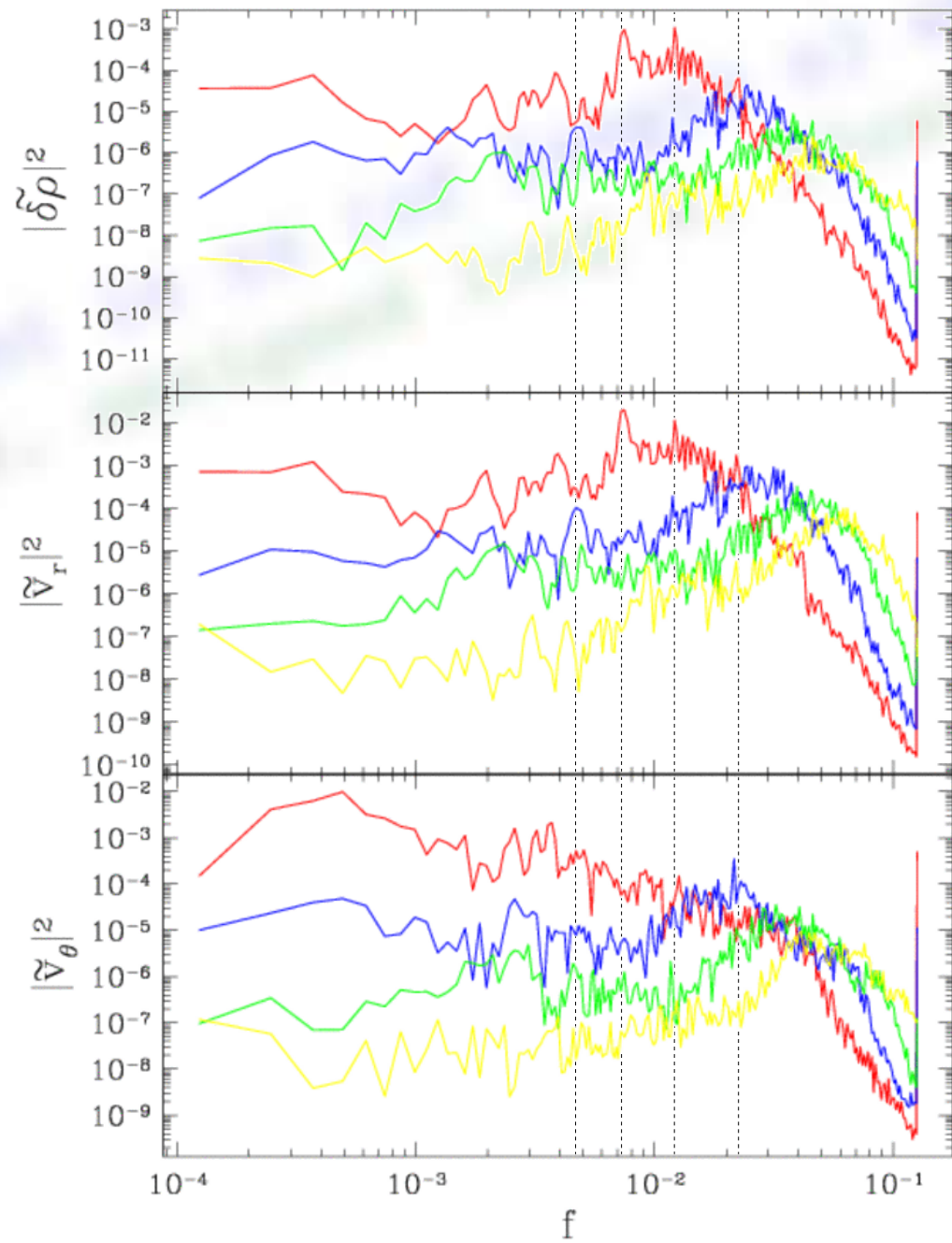
# /\* Finding QPOs in MHD Simulations \*/



- 3 Global MHD runs (Low, Med, High res) show different levels of QPO activity.
- Disagreement between frequencies is "interesting..." Resolution effects?
- Radial bins, Pressure corrections...



Domain Averaged Point FFT

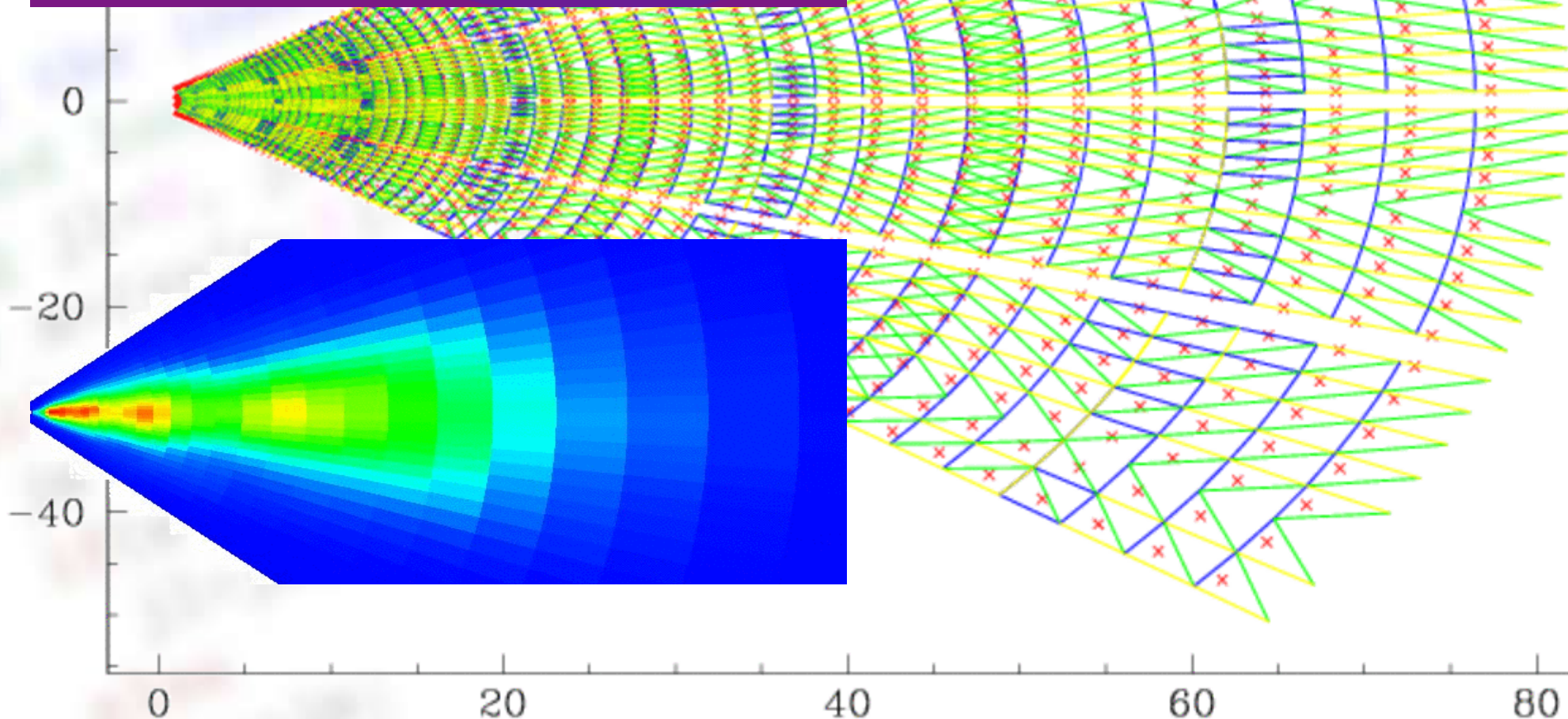
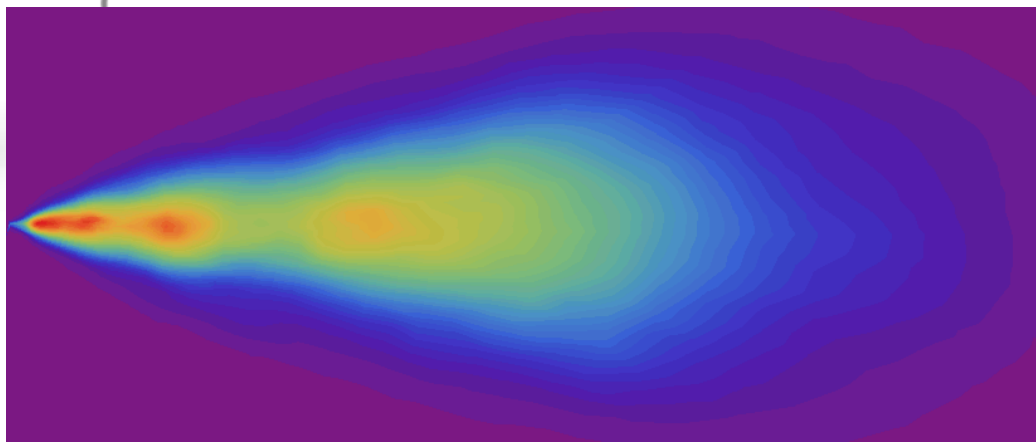


Mode Projection FFT

# /\* Hydrodynamic Modes? \*/

- Low **magnetic** pressure relative to **gas** pressure may indicate PPI >>  
**Simulations of Hydrodynamic Inner Tori**
- **Pitfalls** associated with running a **useful** hydro sims:
  - Initial power-law **angular momentum** distributions cannot match MHD runs >>  
**Import initialization from MHD run**
  - MHD runs' **grids** have different resolutions >> **Interpolate Data**

`/*Torus Initialization*/`



# `/* Preliminary Results */`

- Despite some yet-to-be-dispelled concerns, we have results!
- Qualitatively, structures look comparable to the MHD simulation
- What Next?  $\ll$  Growth rate, Saturation, Momentum Flux...

