

Dynamo

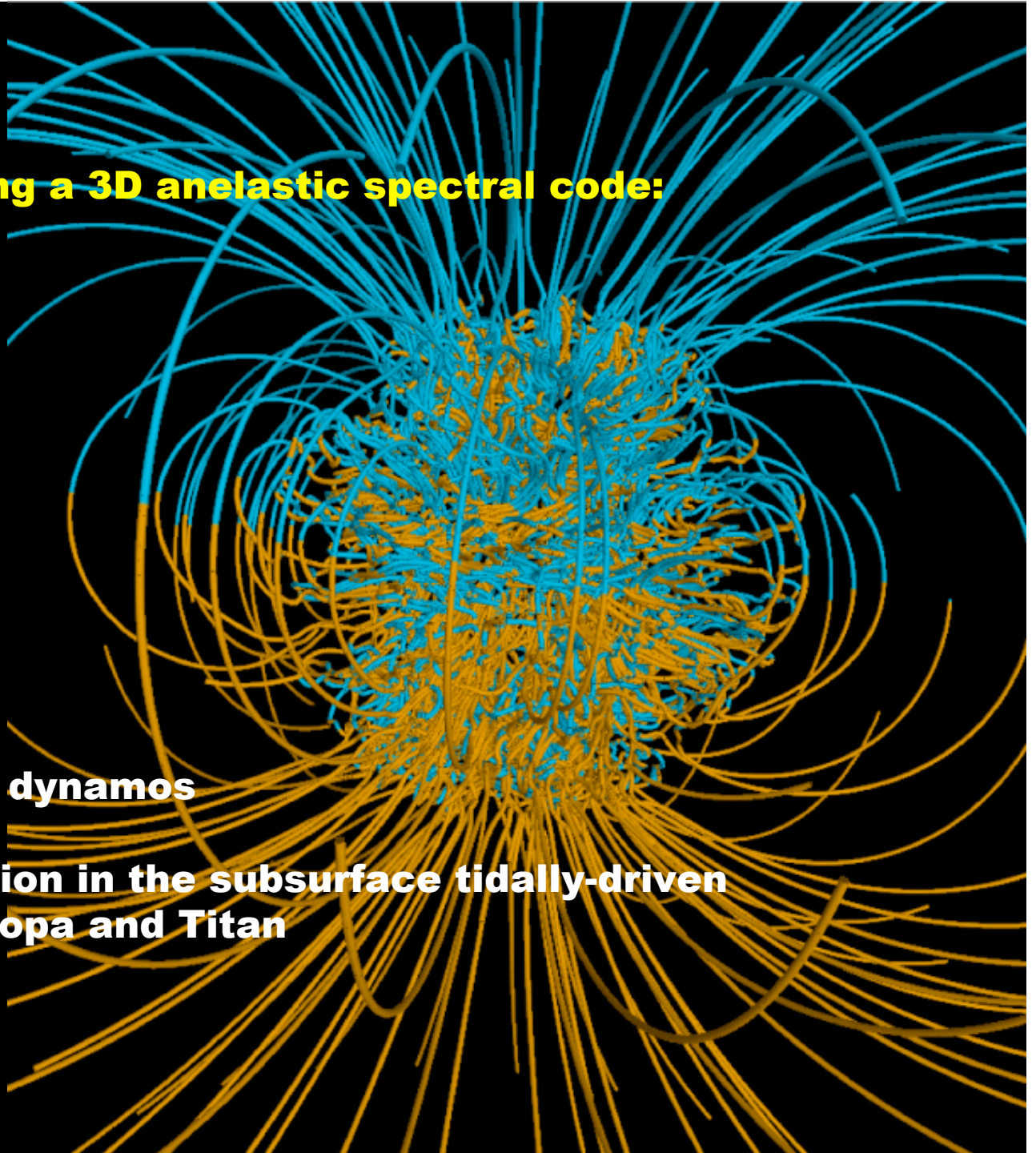
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MHD simulations using a 3D anelastic spectral code:

Stellar and planetary dynamos

**Magnetic field induction in the subsurface tidally-driven
oceans of Europa and Titan**



**An idea:
add magnetic fields
to MAESTRO and CASTRO**

Gauss' Law

$$\nabla \cdot \mathbf{B} = 0$$

**poloidal toroidal
decomposition**

Magnetic induction Eq

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) - \nabla \times (\eta \nabla \times \mathbf{B})$$

Lorentz force density

$$\mathbf{J} \times \mathbf{B}$$

Ampere's Law

$$\mathbf{J} = \frac{1}{\mu} \nabla \times \mathbf{B}$$

Ohmic heating

$$\frac{1}{\sigma} \mathbf{J}^2$$

EM energy flux (Poynting Flux)

$$\frac{1}{\mu} \mathbf{E} \times \mathbf{B}$$

Ohm's law

$$\mathbf{E} = \frac{1}{\sigma} \mathbf{J} - \mathbf{v} \times \mathbf{B}$$

A new simulation:

Closely orbiting binary system (e.g., pre-Type Ia SN)

Simulate the interior dynamics of both stars

nuclear reactions

thermal and compositional convection

magnetic field generation

rotational and tidal forces

while simulating the exterior interactions between the stars

self-gravity

mass transfer

radiative transfer

magnetic interactions

To investigate how magnetic forces and heating affect fluid flow both within the stellar interiors and between the stars.

Codes(?)

MAESTRO:

**low Mach number ($v \ll$ sound speed)
for interiors of the stars**

CASTRO:

**fully compressible with radiative transfer
for exterior region and stellar surface layers**

Both with magnetic fields.

Couple these?

two MAESTRO “stars” embedded in CASTRO “space” (?)

**Or start the stellar simulations without interactions using MAESTRO
and then continue the entire simulation using CASTRO (?)**

Suggestions?