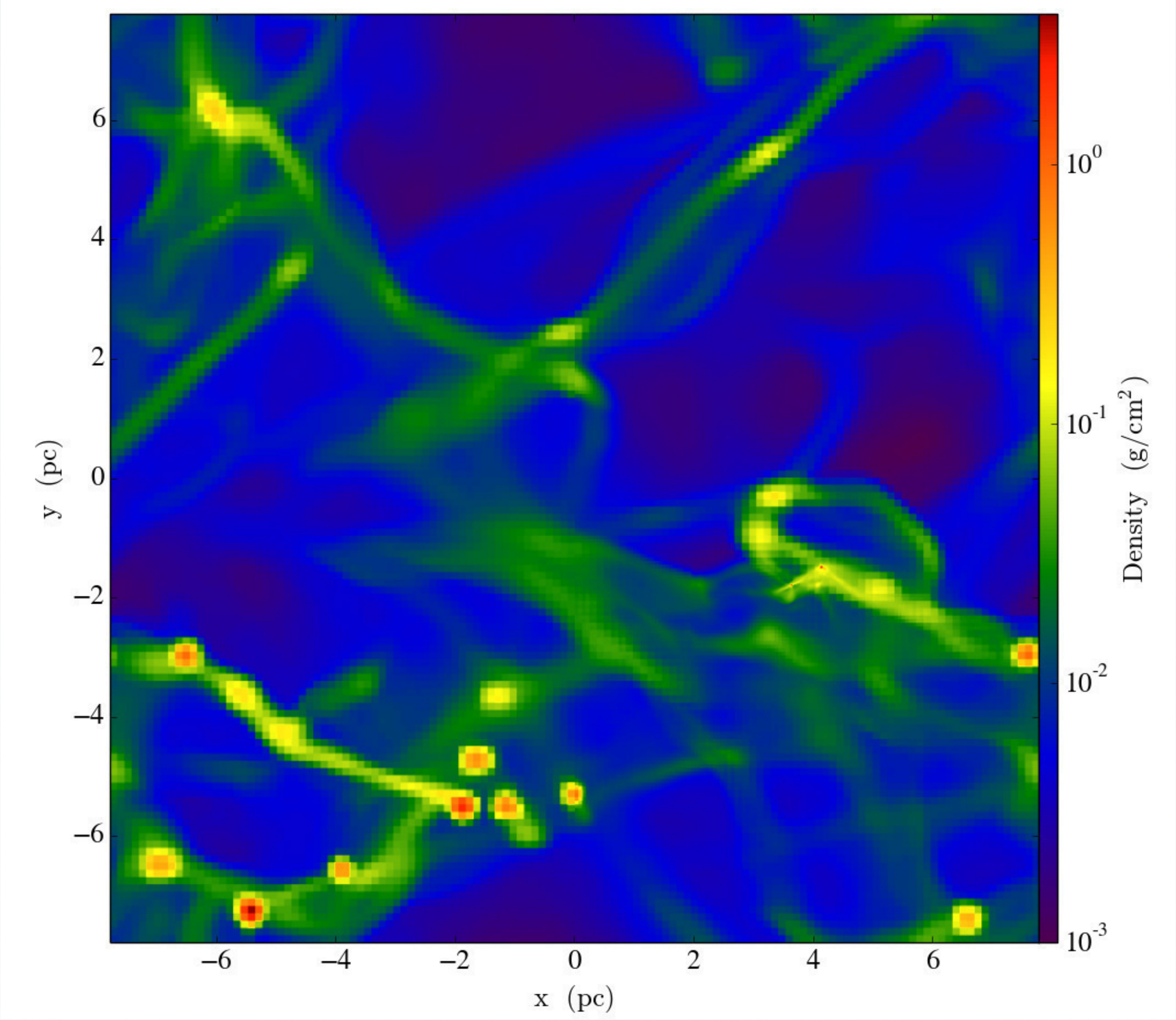
CITA | ICAT

Canadian Institute for Theoretical Astrophysics

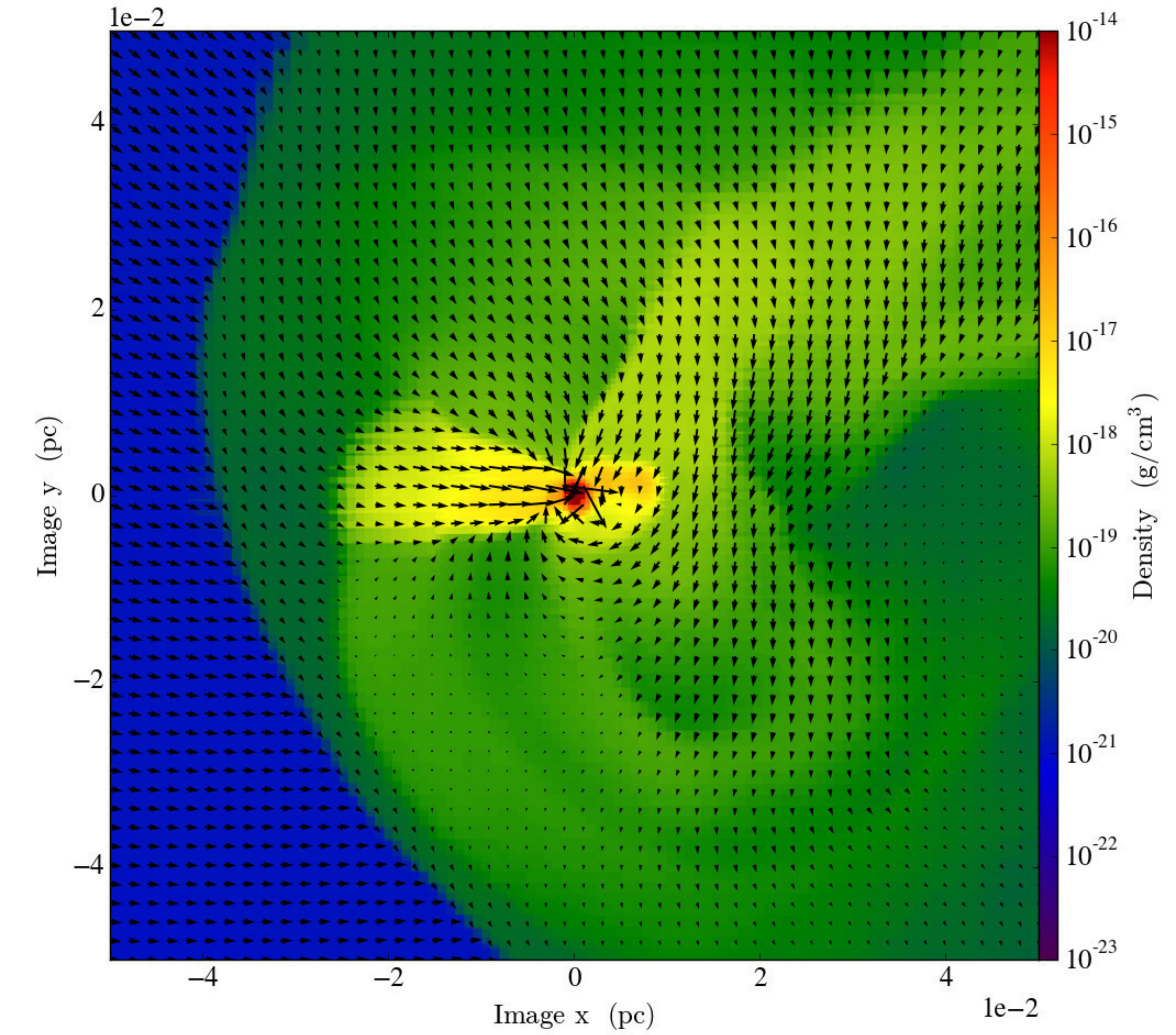
L'institut Canadien d'astrophysique théorique

Jamboree 2015

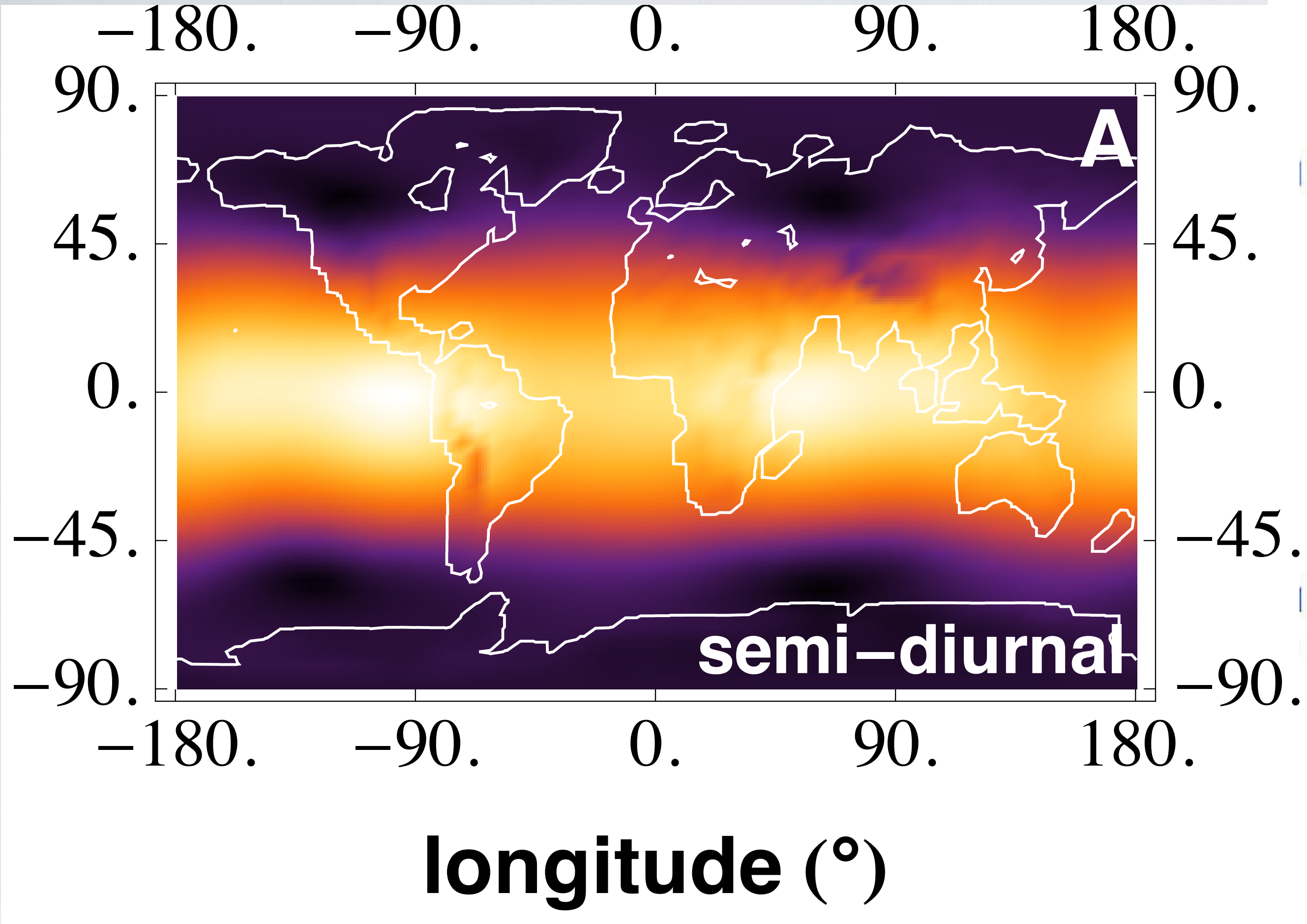


GALAXY & STAR FORMATION

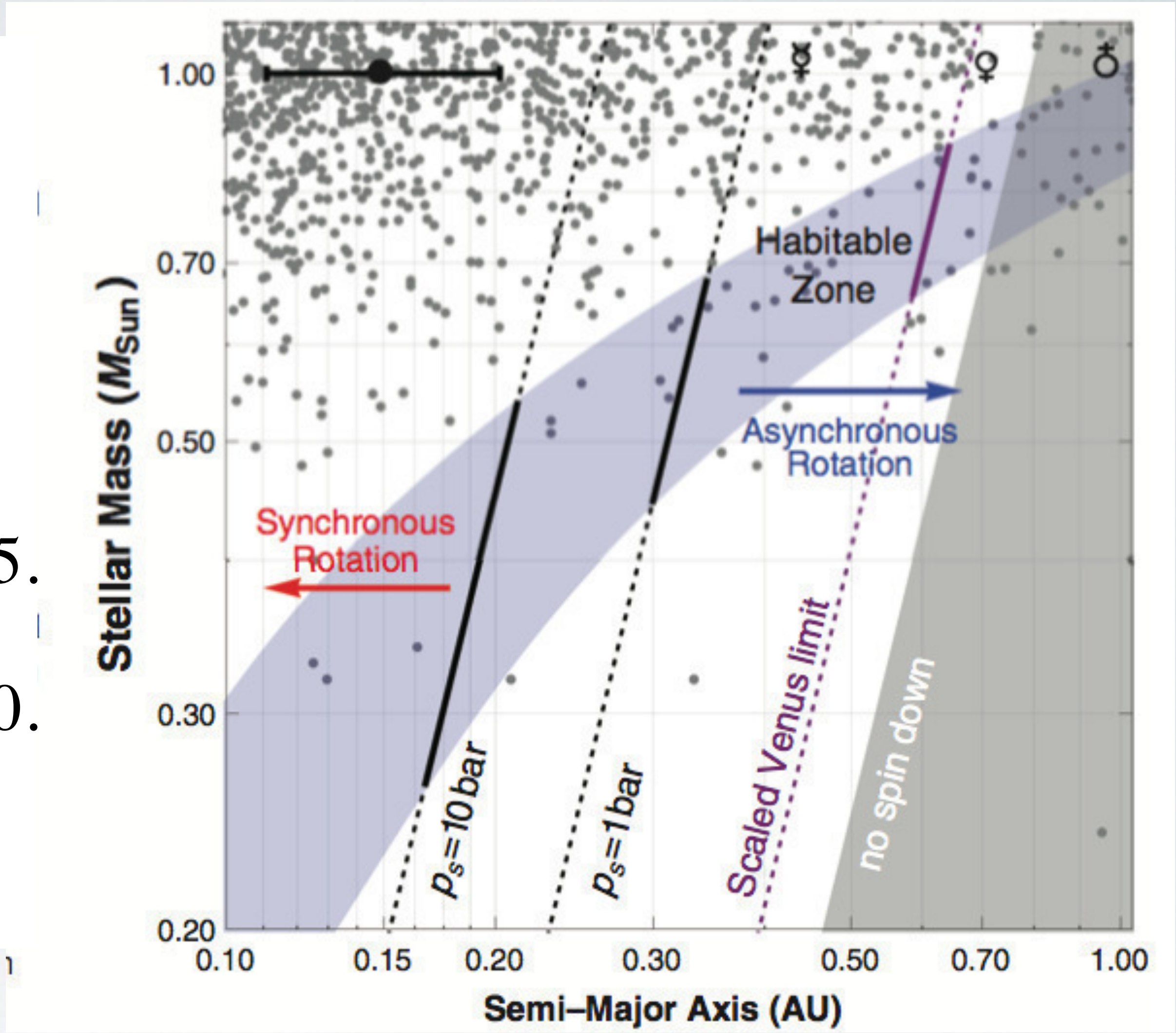
Norman Murray



1e−2
Image y (pc)
4
2
0
−2
−4
−4
−2
0
2
4
Image x (pc)
1e−2
Density (g/cm^3)
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}



A
semi−diurnal
longitude (°)

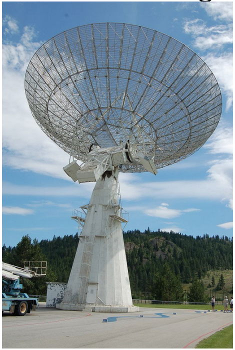


Habitable Zone
Asynchronous Rotation
Synchronous Rotation
p_s=10 bar
p_s=1 bar
Scaled Venus limit
no spin down
Stellar Mass (M_{Sun})
Semi–Major Axis (AU)

image credit: Andre Recnik

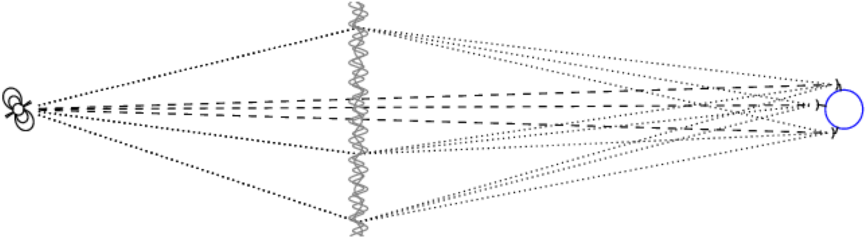
Pulsar VLBI

- coherent, unresolved point sources
- radar/holography imaging through ISM
- potential for imaging pulsar magnetosphere, ISM.

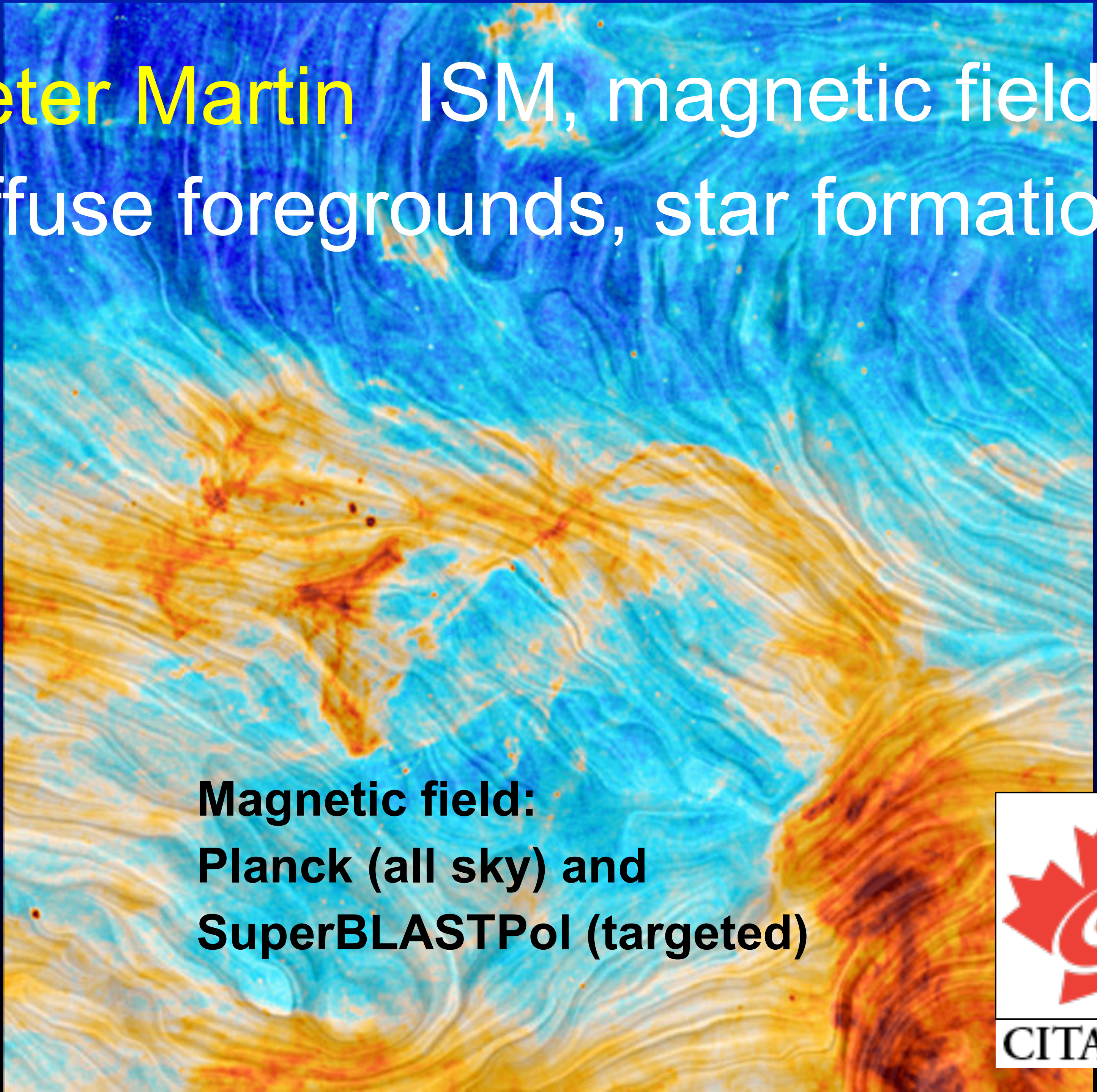


New Pulsar Science

- use interstellar plasma as telescope
- unprecedented angular precision: 50 picoarcseconds



Peter Martin ISM, magnetic fields, diffuse foregrounds, star formation

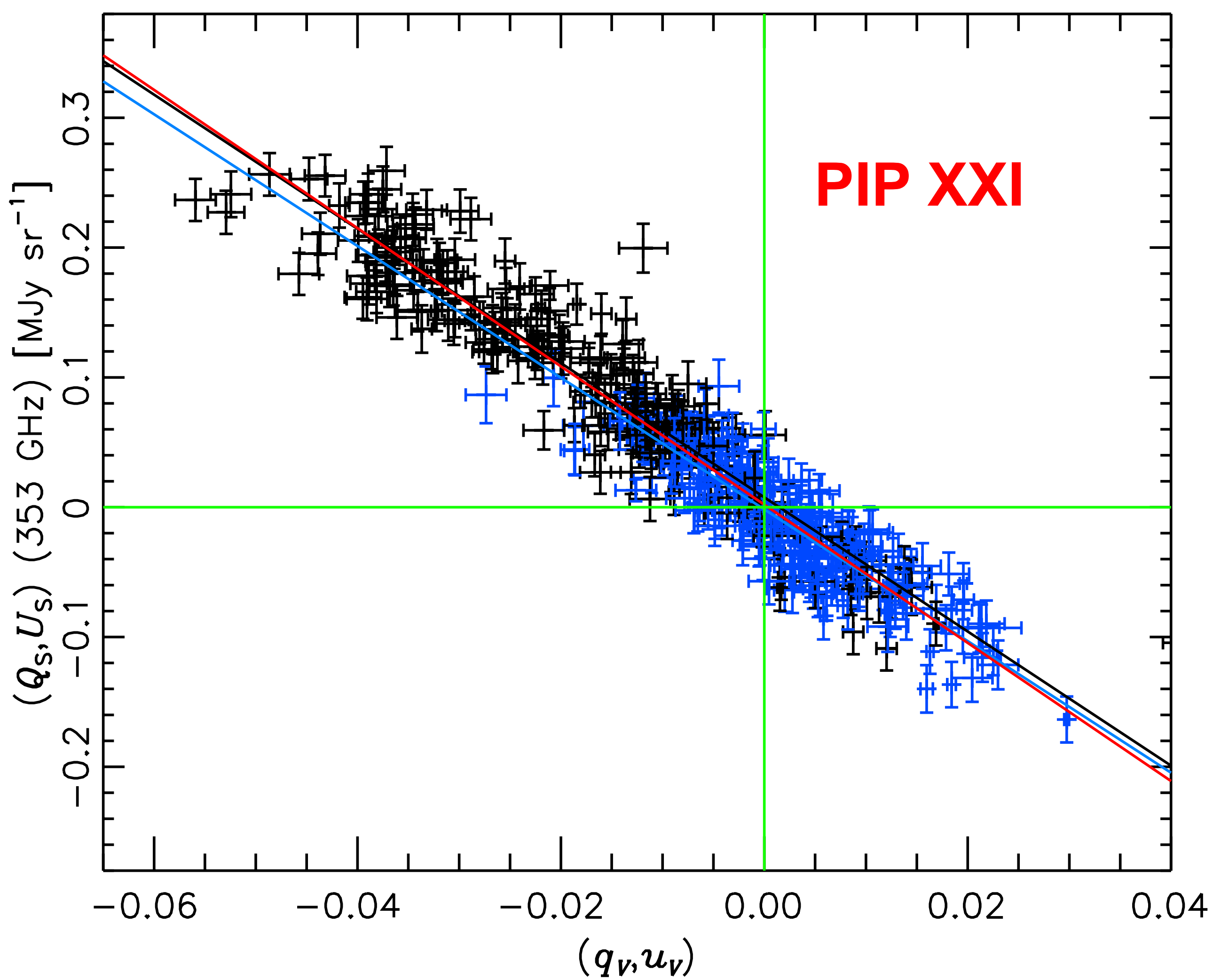


Magnetic field:
Planck (all sky) and
SuperBLASTPol (targeted)

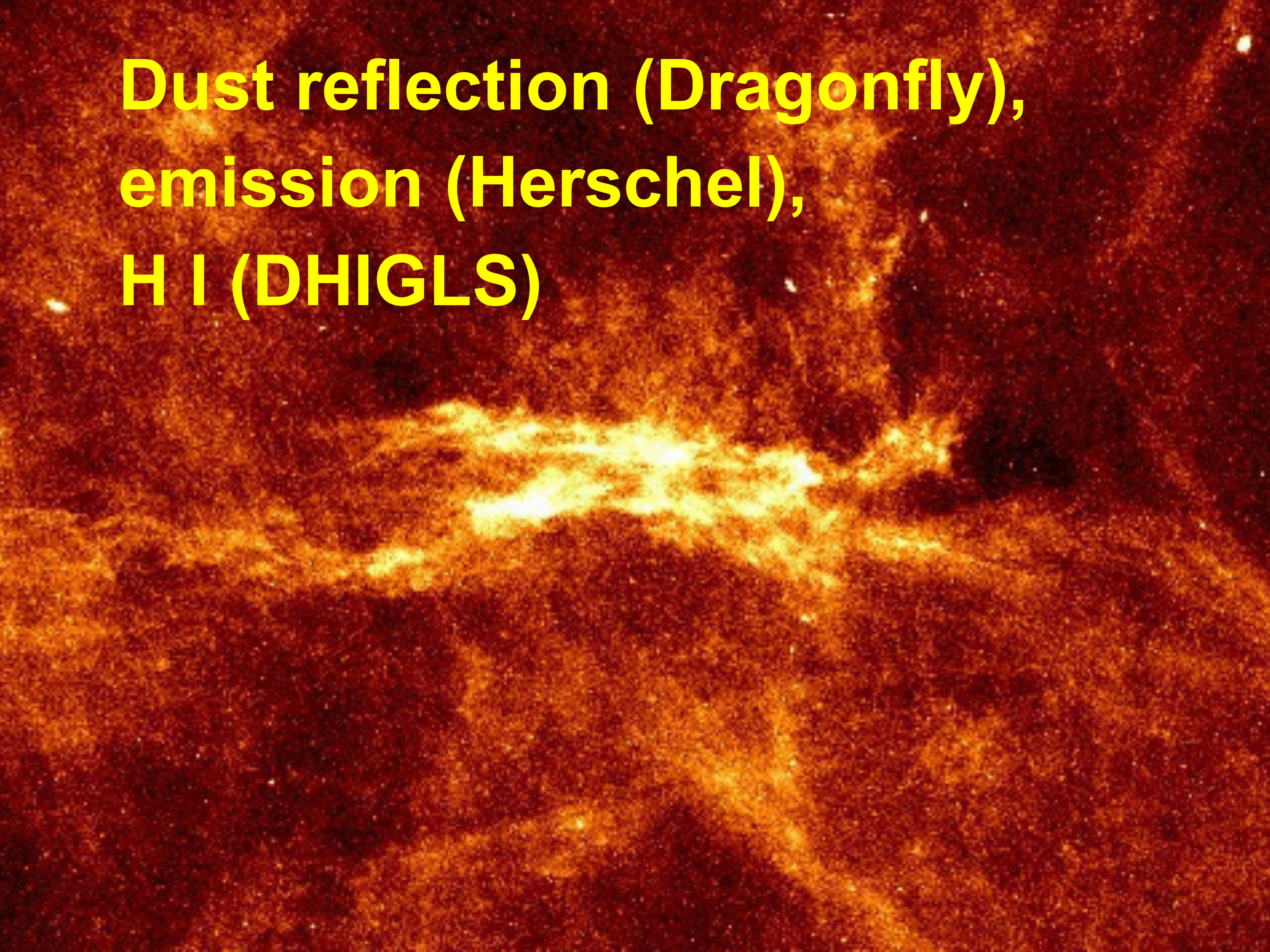
CITA–ICAT

P(submm) vs. p_V (visible)
emission extinction

Tightly correlated.
Slope: Constraint on grain models
Model predictions low by factor ~2.5




Dust reflection (Dragonfly),
emission (Herschel),
H I (DHIGLS)


Dust reflection (Dragonfly),
emission (Herschel),
H I (DHIGLS)


Dust reflection (Dragonfly),
emission (Herschel),
H I (DHIGLS)

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Jamboree 2015

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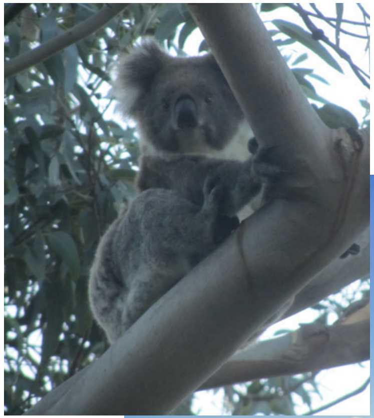
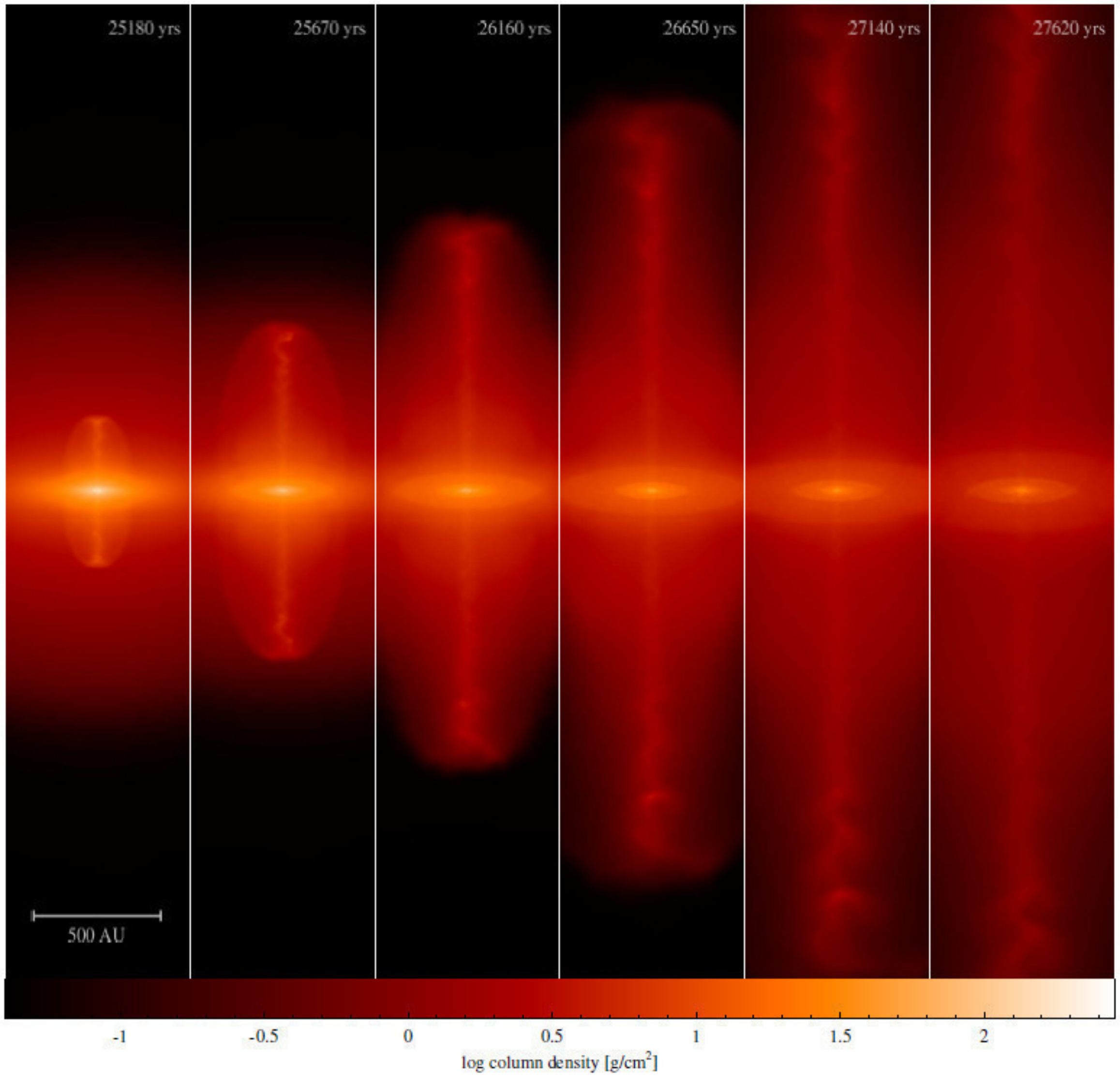
CHRIS THOMPSON
Professor
high-energy astrophysics, neutron stars, magnetars

Star Formation and Numerical MHD

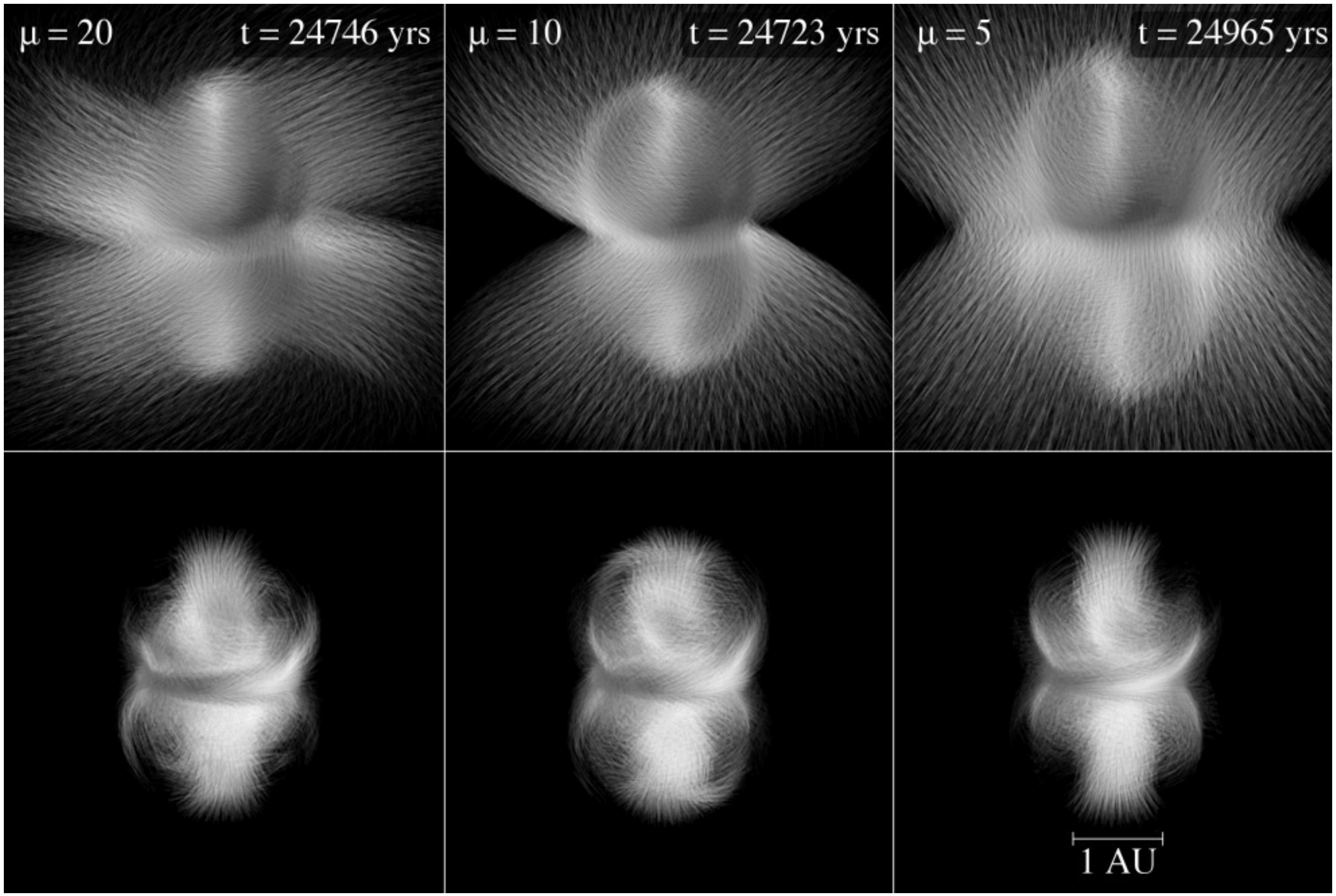
Terrence Tricco
BSc, MSc, Memorial University of Newfoundland, Canada
PhD, Monash University, Australia
Post-doc, University of Exeter, UK



Low-mass Star formation (~1$M_\odot$)

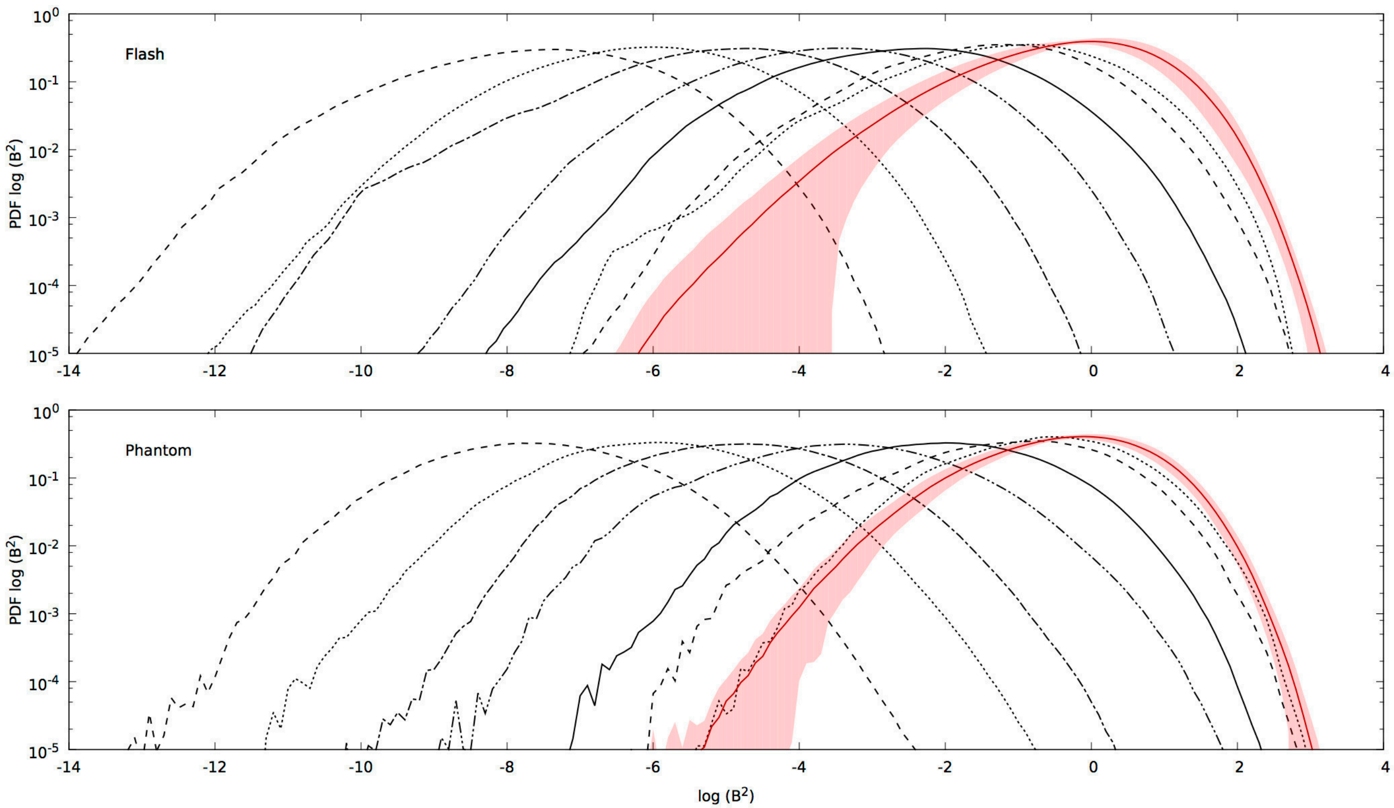


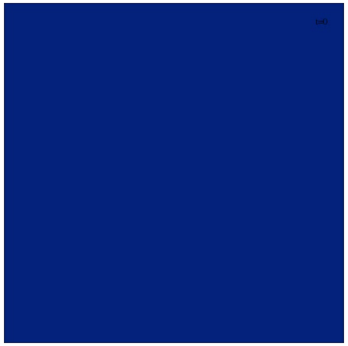
Low-mass Star formation (~$1M_\odot$)

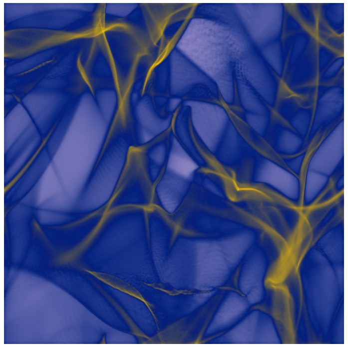


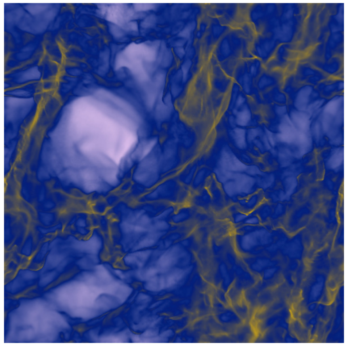
Magnetised Turbulence in Molecular Clouds: `Turbulence-in-a-box'

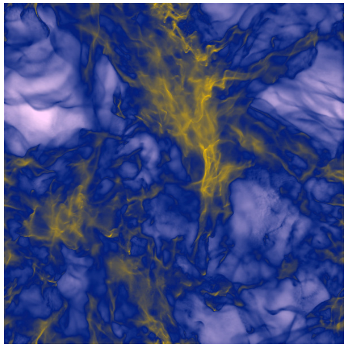
- Small-scale turbulent dynamo amplification of magnetic fields



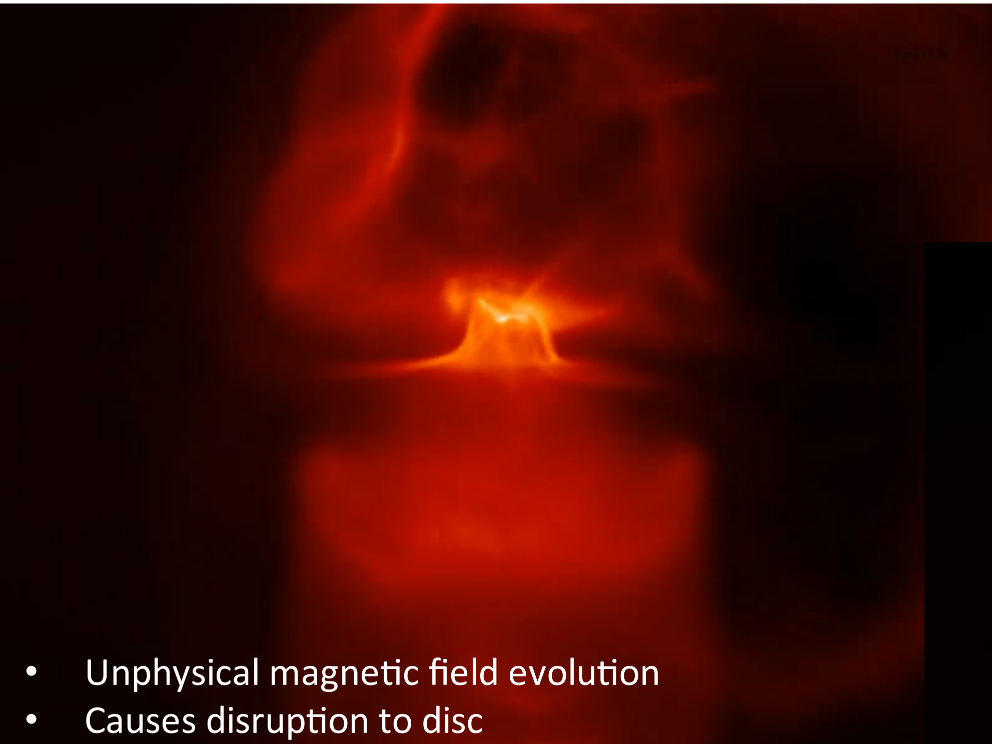




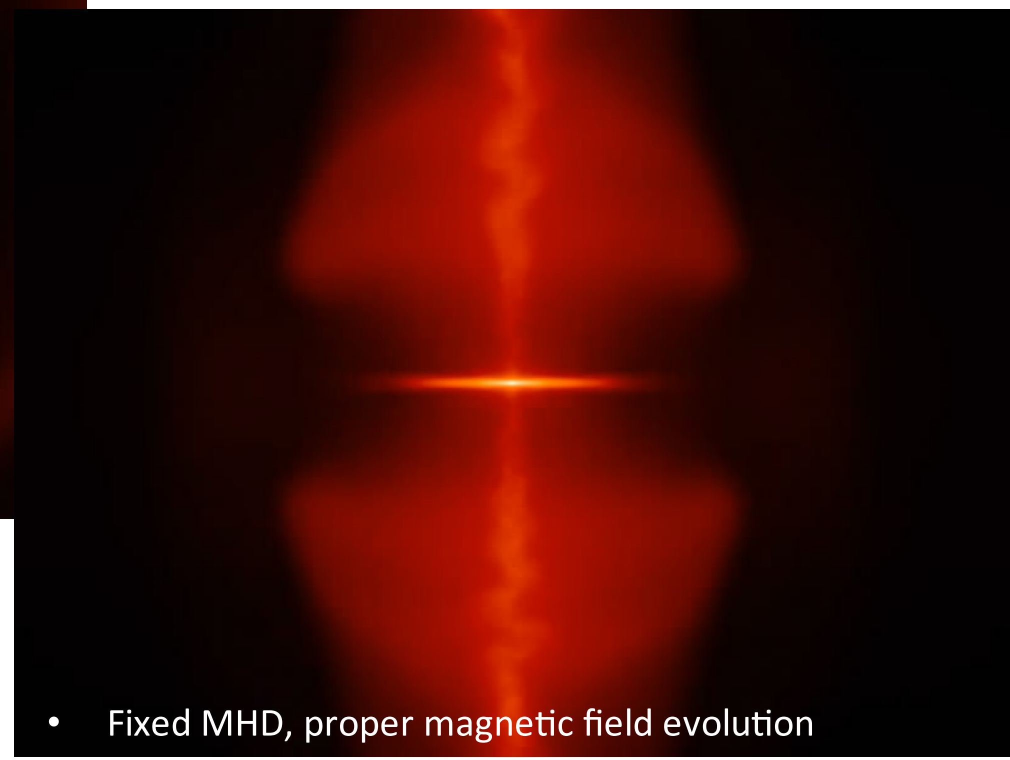




Particle-based MHD

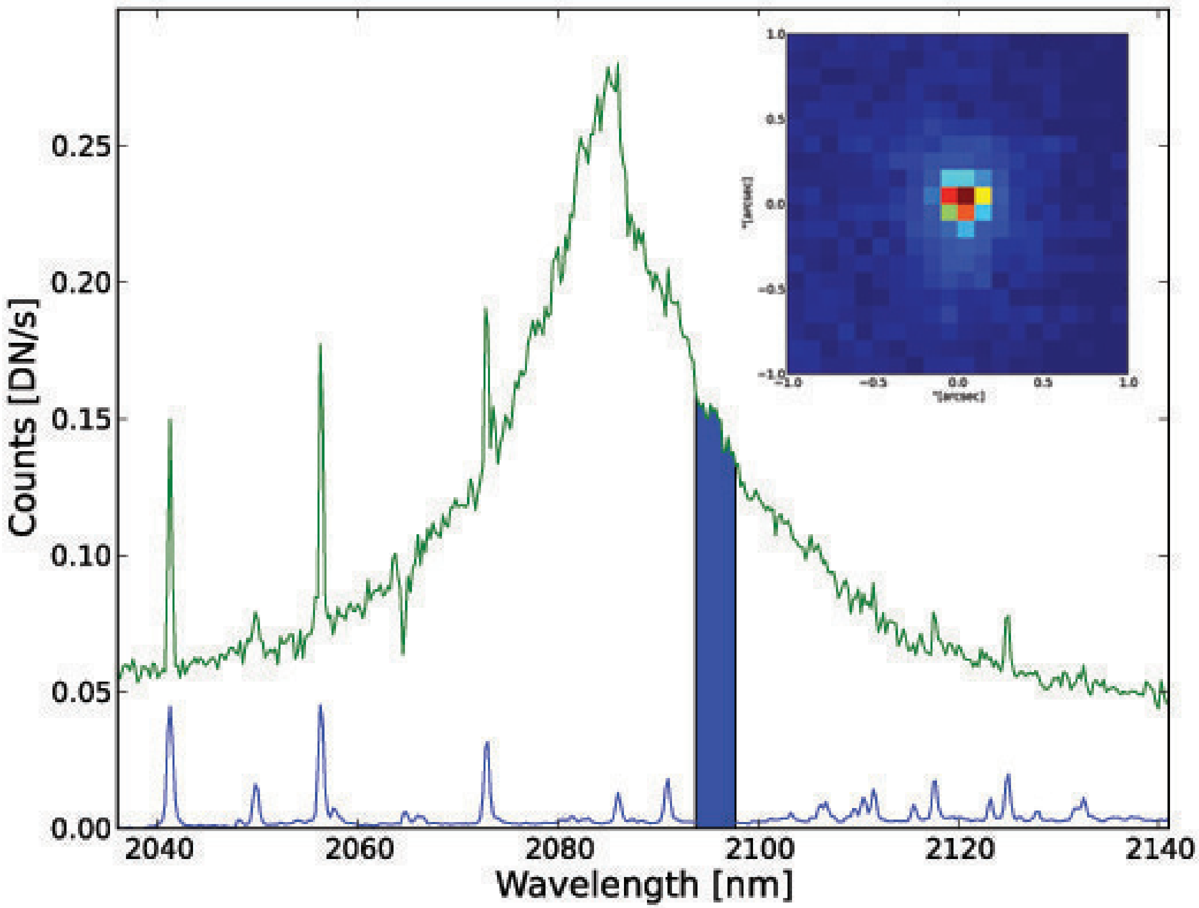


- Unphysical magnetic field evolution
- Causes disruption to disc

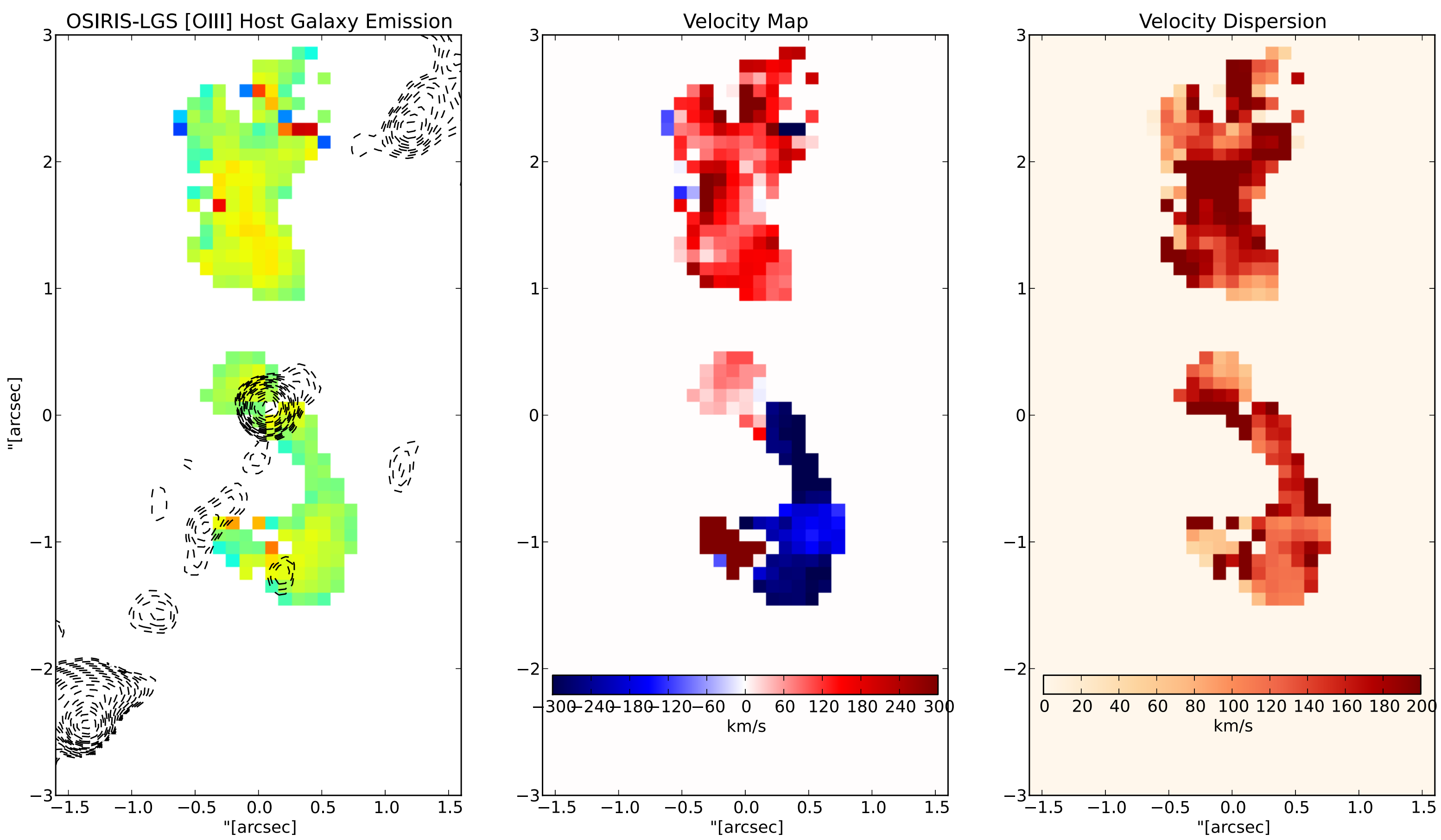


- Fixed MHD, proper magnetic field evolution

PSF construction from the broad line emission of a quasar



Latest results

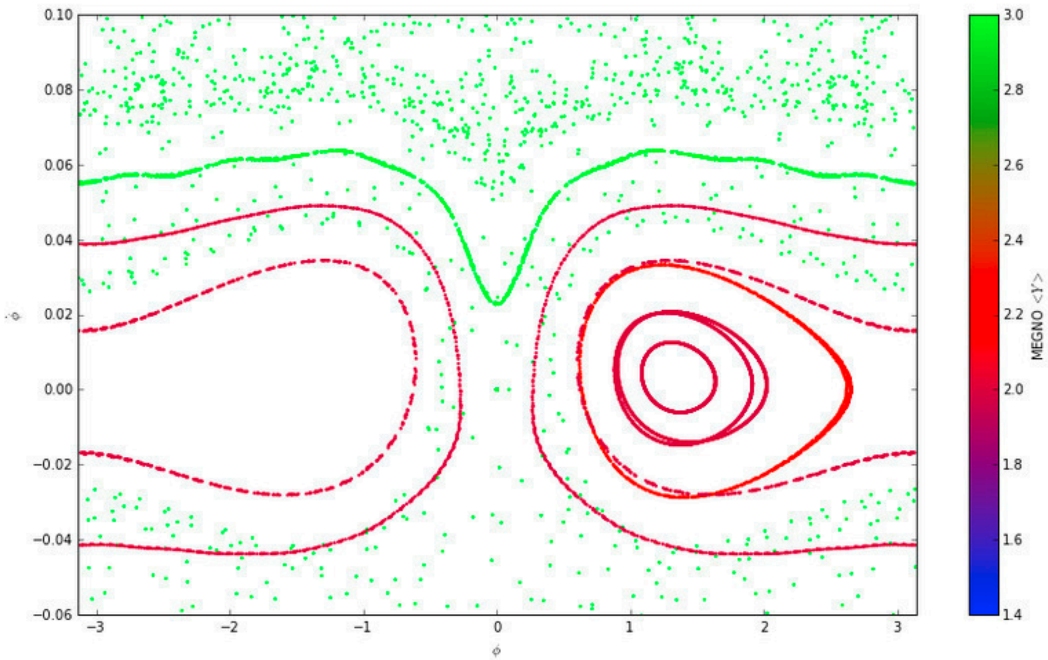


Architectures of Planetary Systems

Dan Tamayo
CITA / CPS

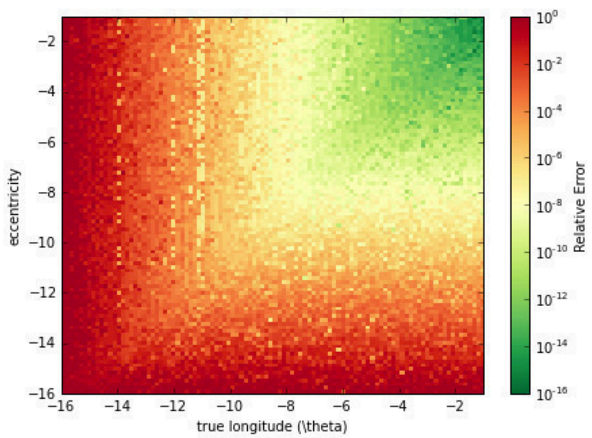
REBOUND:
A Modern N-Body Integrator

In [11]:
```
%matplotlib inline
import matplotlib.pyplot as plt
fig = plt.figure(figsize=(14,8))
ax = plt.subplot(111)
ax.set_xlabel("$\phi$"); ax.set_ylabel("$\dot{\phi}$")
ax.set_xlim([-np.pi,np.pi]); ax.set_ylim([-0.06,0.1])
cm = plt.cm.get_cmap('brg')
for m, megno, vx in res:
    c = np.empty(len(m[:,0])); c.fill(megno)
    p = ax.scatter(m[:,0],m[:,1],marker=".",c=c, vmin=1.4, vmax=3,  s=25,edgecolor='none',
cmap=cm)
cb = plt.colorbar(p, ax=ax)
cb.set_label("MEGNO $<Y>$")
```

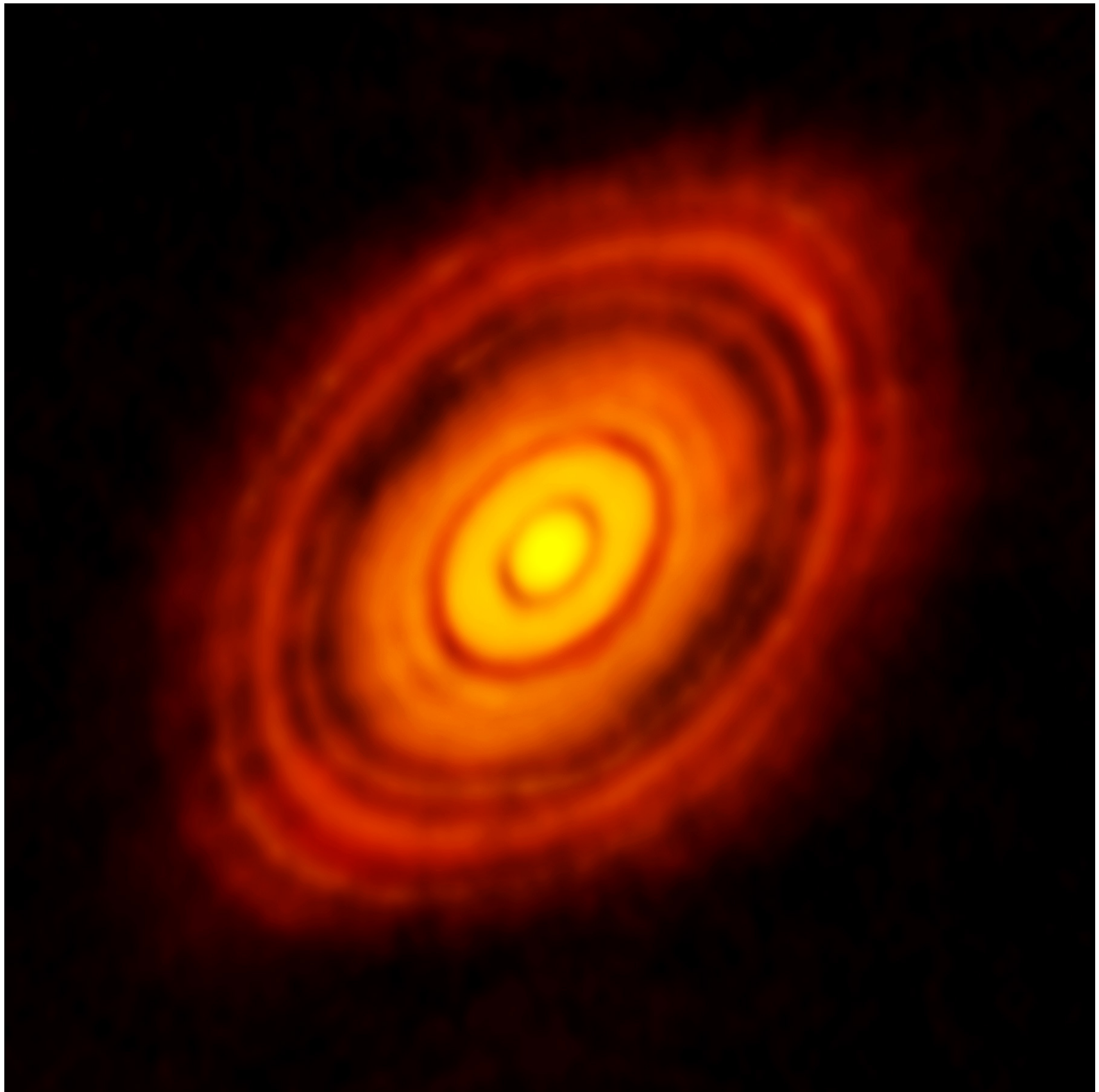


The red orbits are periodic or quasi periodic, the green orbits are chaotic.

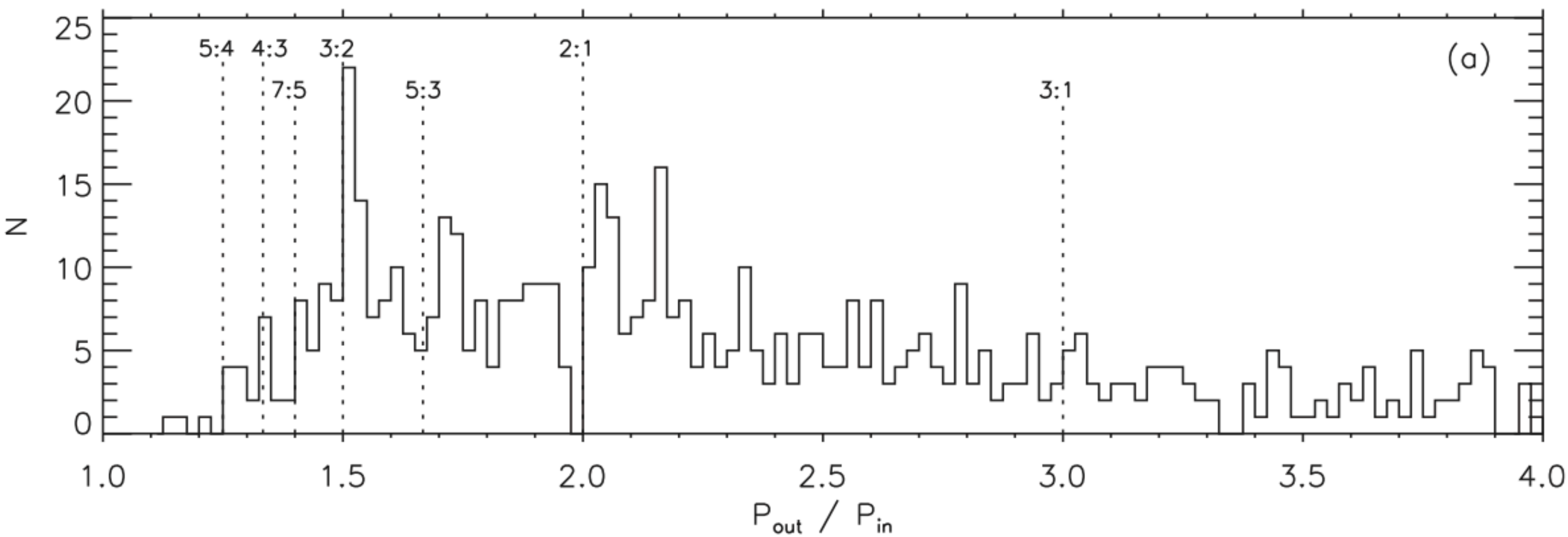
In [6]:
```
def simulation(par):
    e,theta = par
    e = 10**e
    theta = 10**theta
    sim = rebound.Simulation()
    sim.add(m=1.)
    a = 1.
    inc = random.random()*np.pi
    Omega = random.random()*2*np.pi
    omega = random.random()*2*np.pi
    sim.add(m=0.,a=a,e=e,inc=inc,Omega=Omega, theta=theta)
    o=sim.calculate_orbits()[0]
    if o.theta < 0:
        o.theta += 2*np.pi
    err = max(np.fabs(o.e-e)/e, np.fabs(o.theta-theta)/theta)
    return err

random.seed(1)
N = 100
es = np.linspace(-16.,-1.,N)
thetas = np.linspace(-16.,-1.,N)
params = [(e,theta) for e in es for theta in thetas]

pool=rebound.InterruptiblePool()
res = pool.map(simulation, params)
res = np.array(res).reshape(N,N)
res = np.nan_to_num(res)

f,ax = plt.subplots(1,1,figsize=(7,5))
extent=[thetas.min(), thetas.max(), es.min(), es.max()]

ax.set_xlim(extent[0], extent[1])
ax.set_ylim(extent[2], extent[3])
ax.set_xlabel(r"true longitude (\theta)")
ax.set_ylabel(r"eccentricity")

im = ax.imshow(res, norm=LogNorm(), vmax=1., vmin=1.e-16, aspect='auto', origin="lower", in
terpolation='nearest', cmap="RdYlGn_r", extent=extent)
cb = plt.colorbar(im, ax=ax)
cb.solids.set_rasterized(True)
cb.set_label("Relative Error")
```



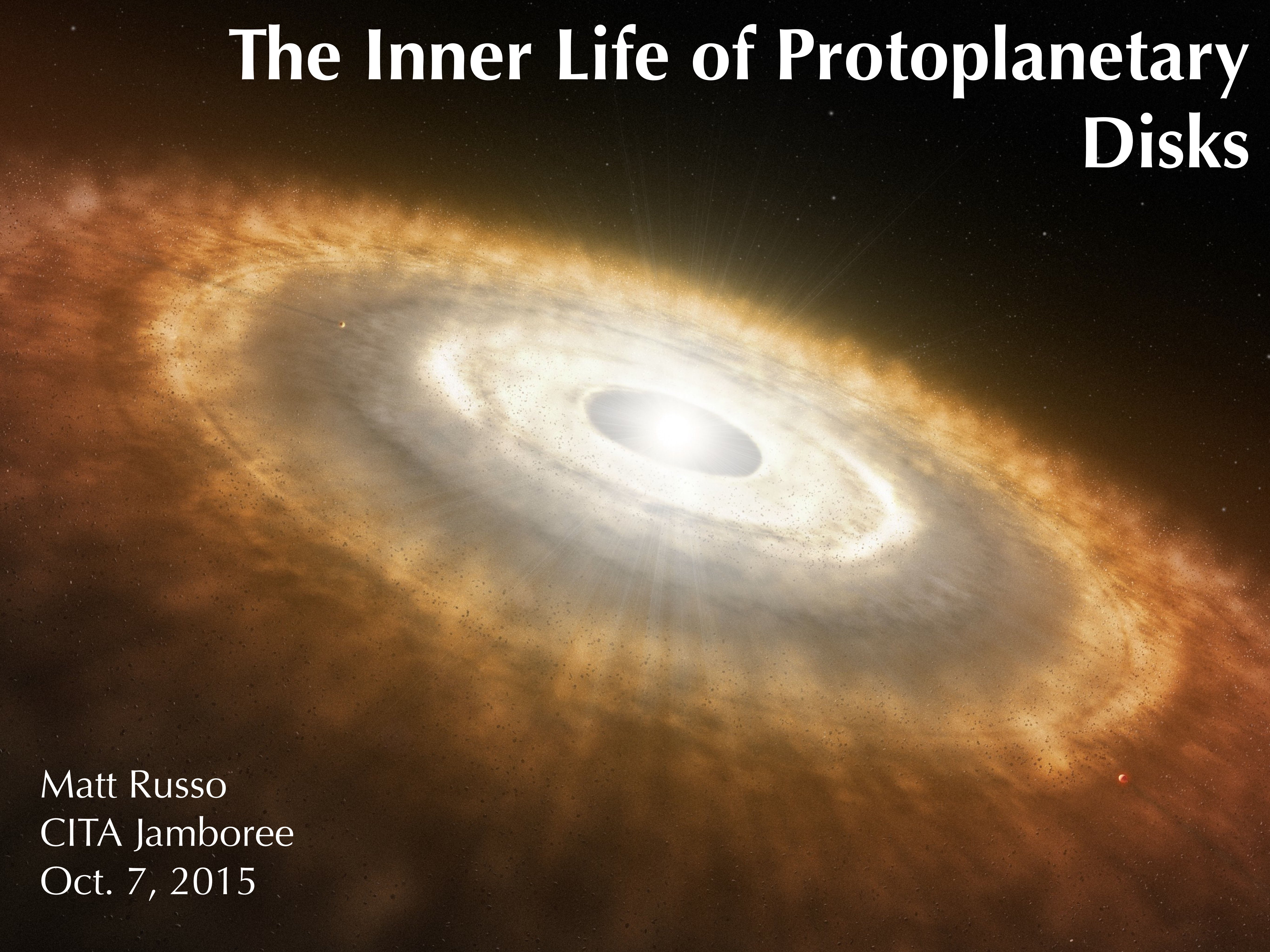
Planet-Disk Interactions



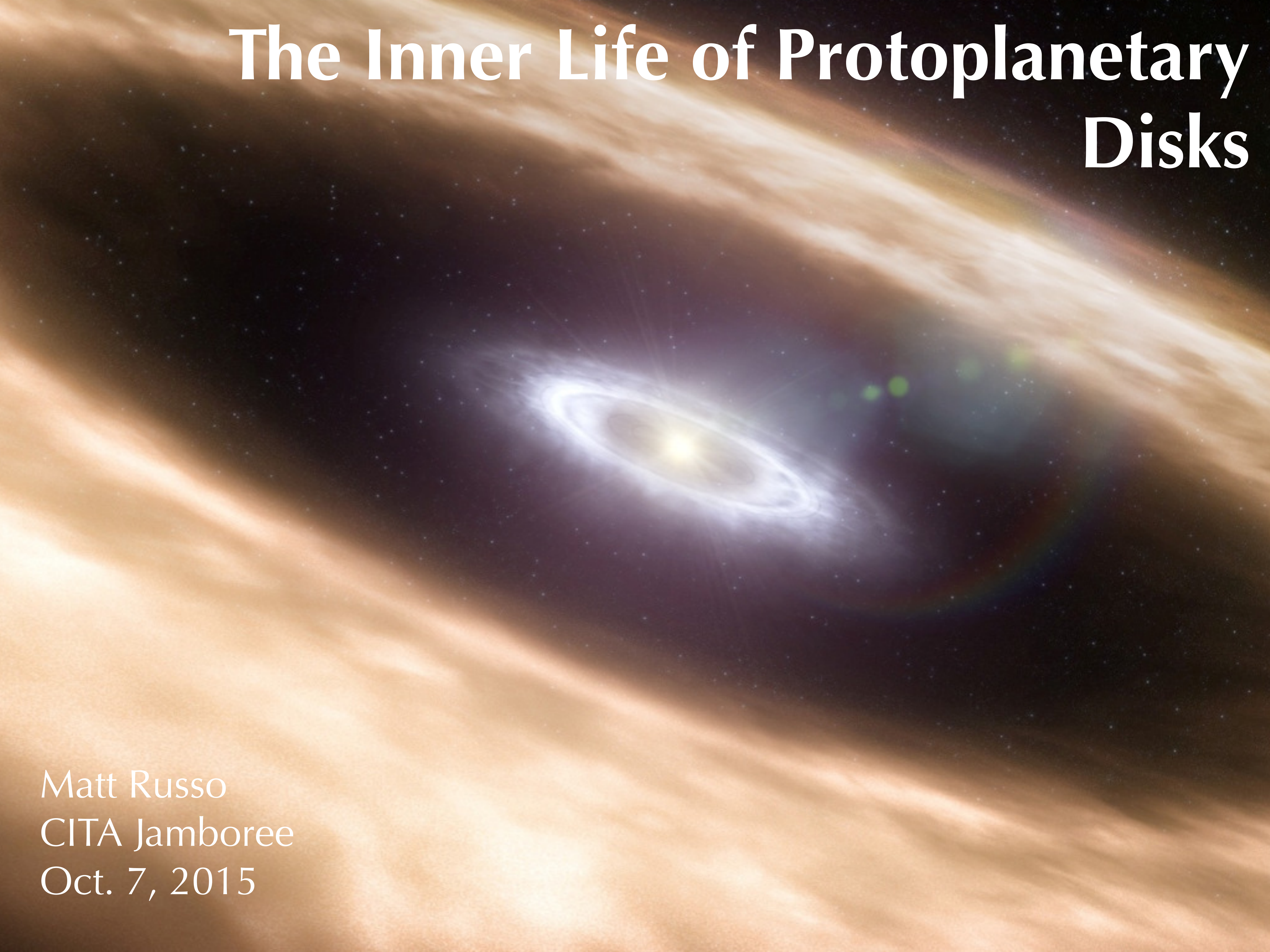
Stability of Resonances



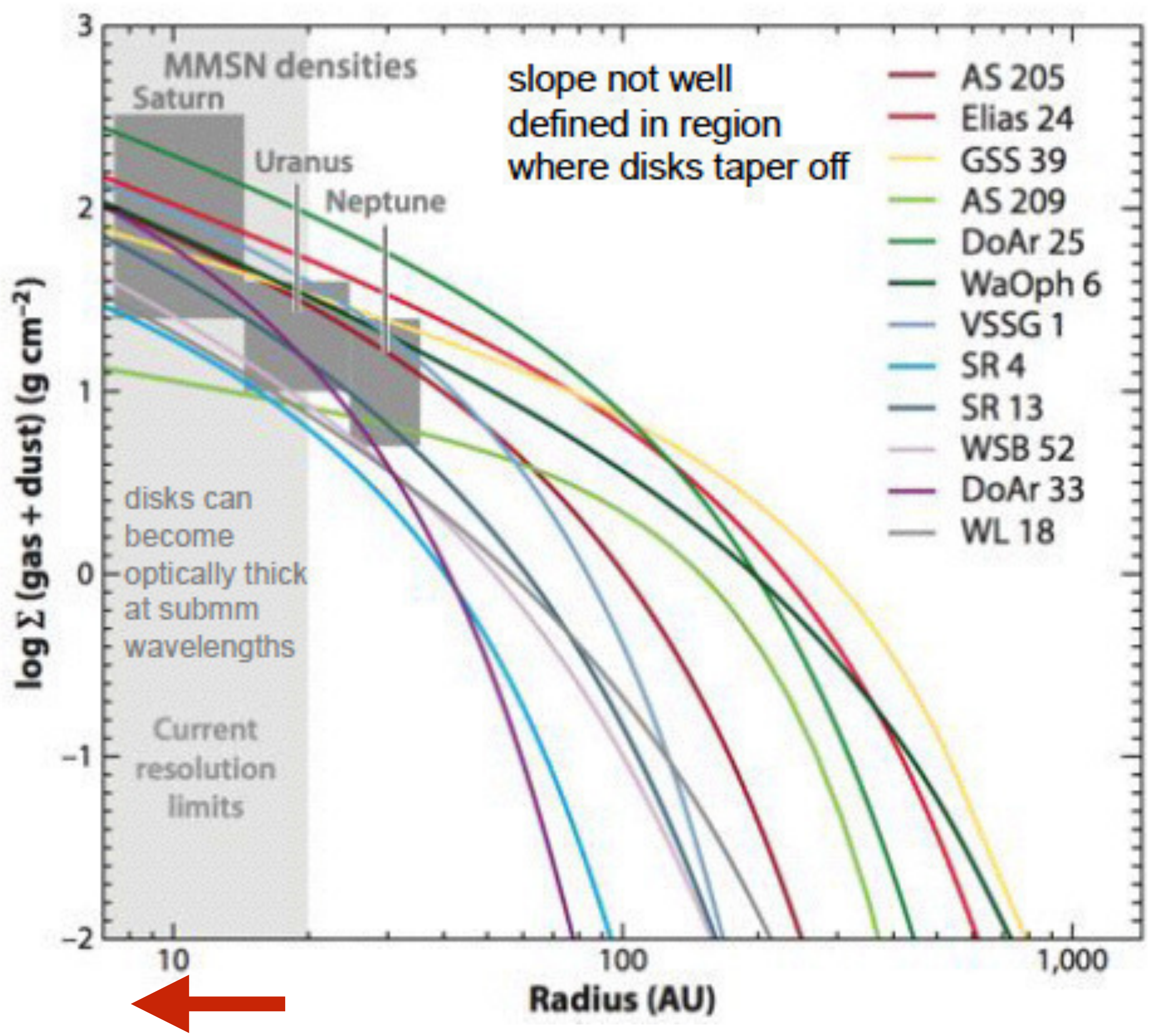
The Inner Life of Protoplanetary Disks



Matt Russo
CITA Jamboree
Oct. 7, 2015


The Inner Life of Protoplanetary Disks
Matt Russo
CITA Jamboree
Oct. 7, 2015

What is the gas density profile in PPDs?



ALMA
(+ optically thin gas line tracers)

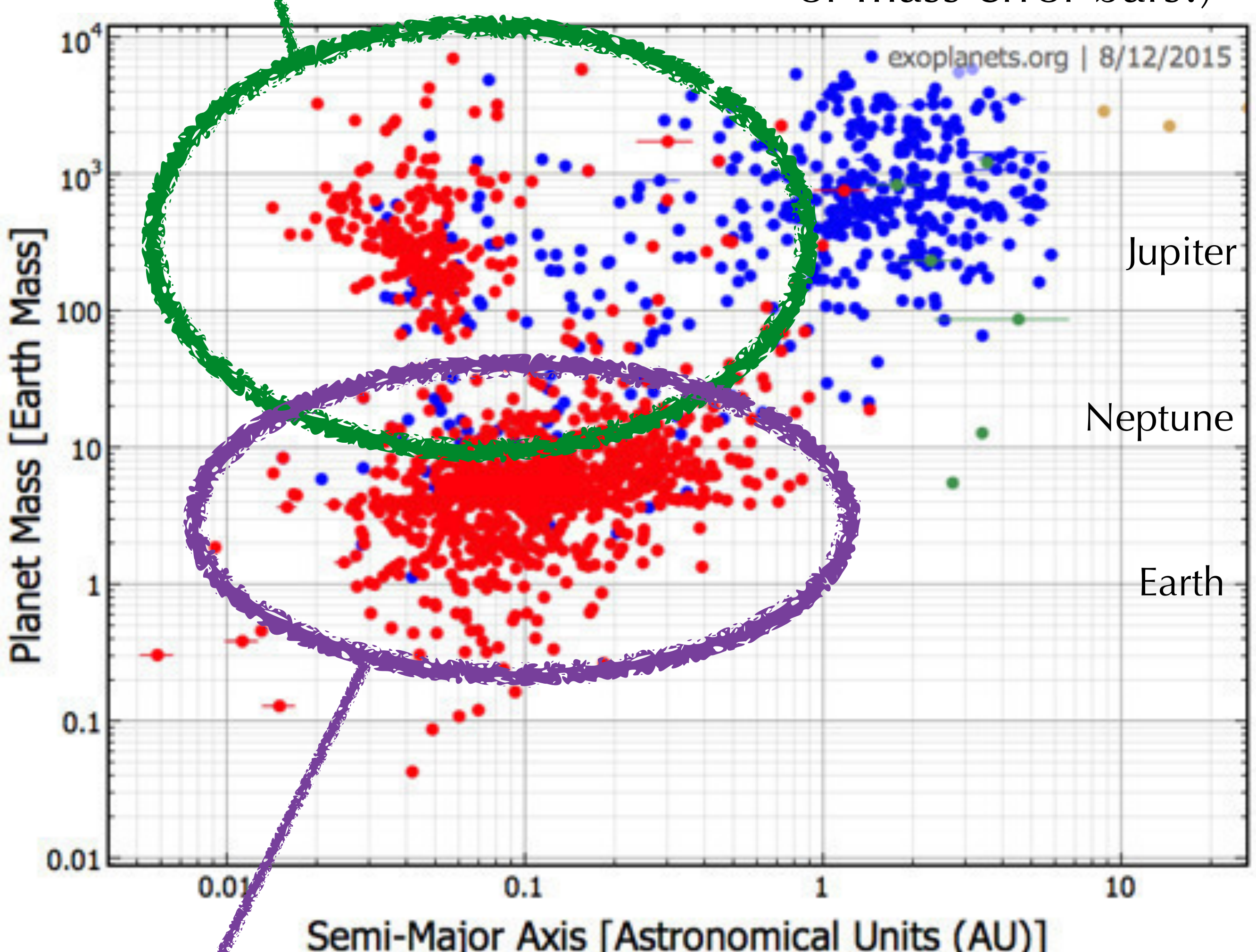
- best tracer: optically thin continuum dust emission (x100)
- fit for self-similar evolution:

$$\Sigma_g \propto r^{-p} \exp\left(-r/r_c\right)$$

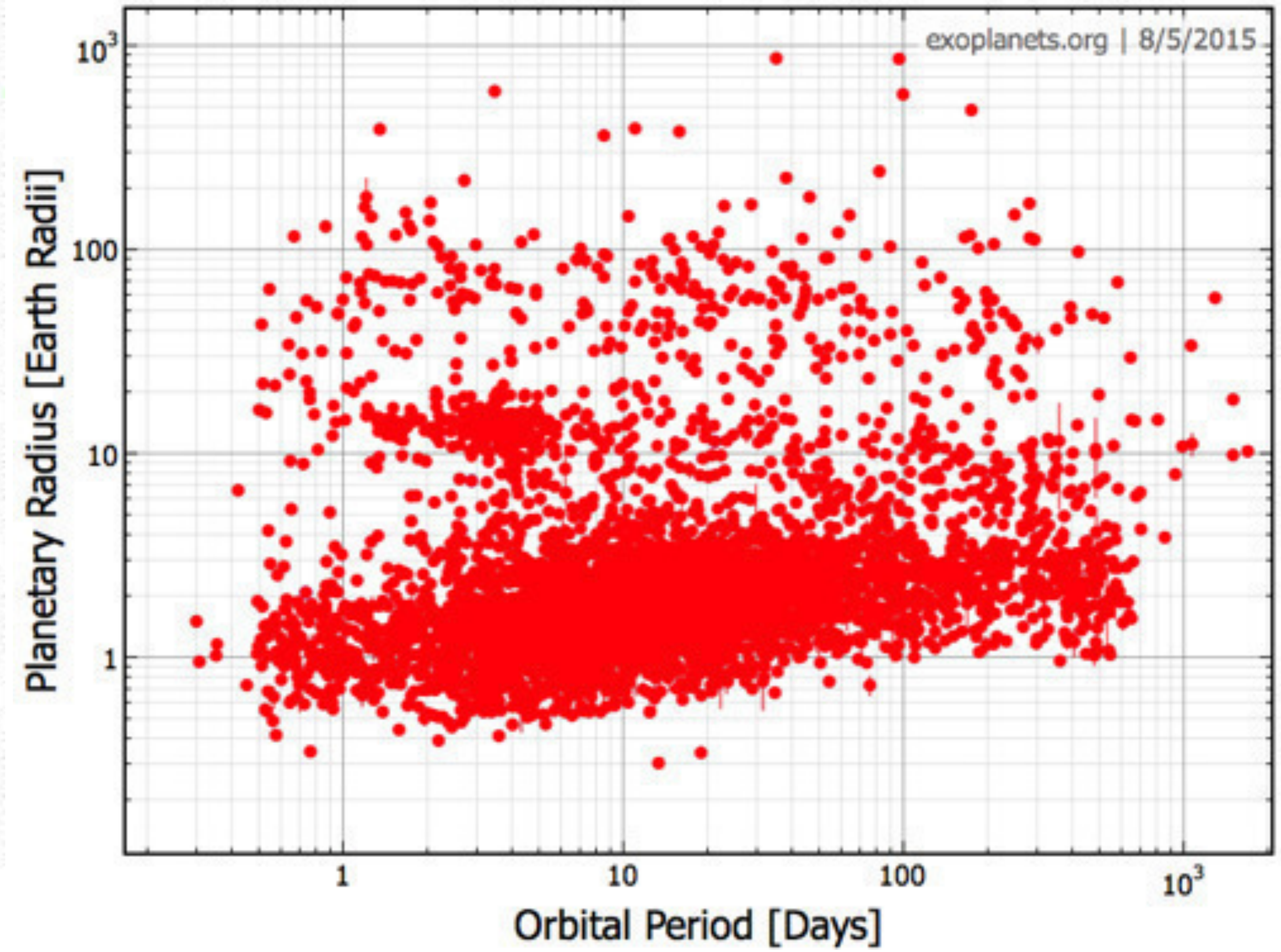
$$< p >= 0.9 \pm 0.2$$ (Andrews et al. 2010)

$$p = -0.8 \text{ to } 0.8$$ (Isella et al. 2009)

(not including Kepler data, or mass error bars!)



(including Kepler data)



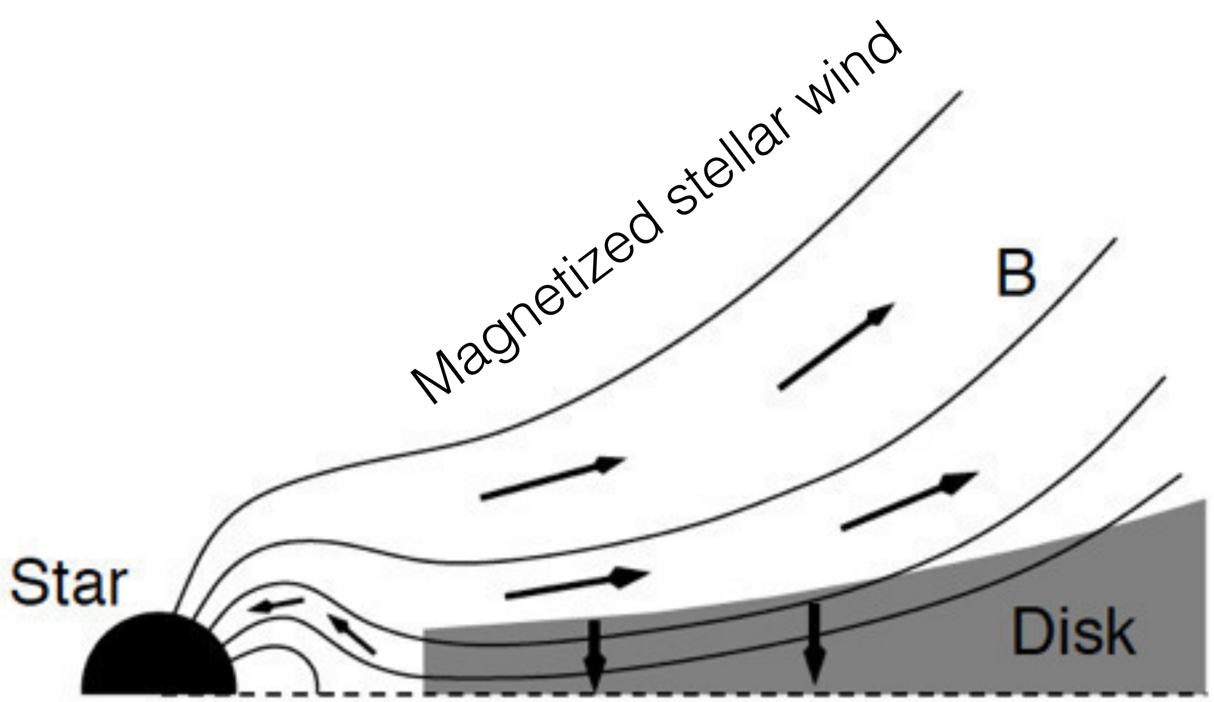
- Type I migration: $t_I \propto M_p^{-1}\Sigma_g^{-1}$
- Type II migration: $t_{II} \propto R^2/\nu$ or $M_p\Sigma_g^{-1}$

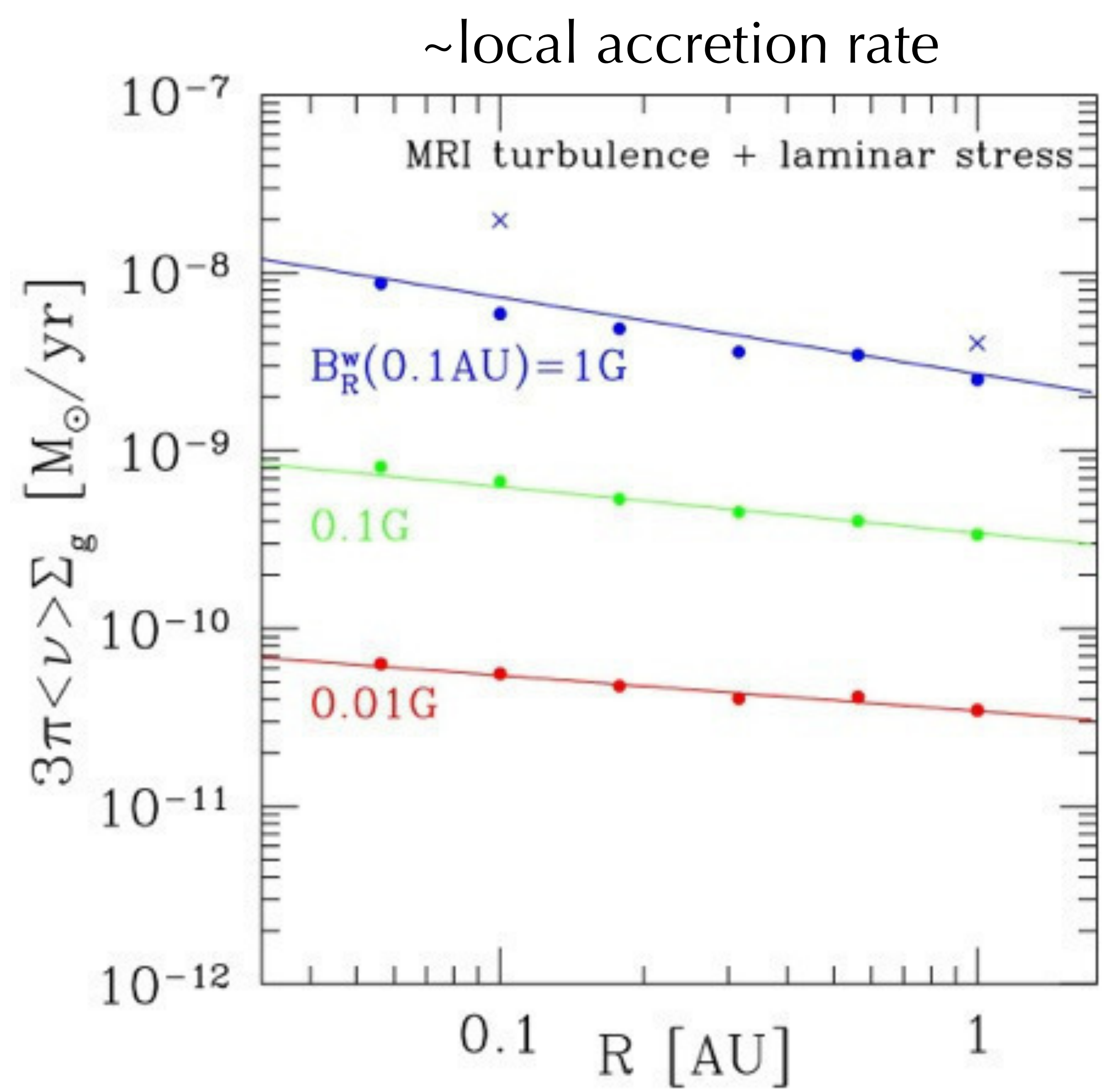
} sensitive to turbulence

A New Approach: Radially Magnetized Disk

$$B_r^w \approx B(R_*) \left(\frac{R_*}{r}\right)^2$$

(`split monopole')

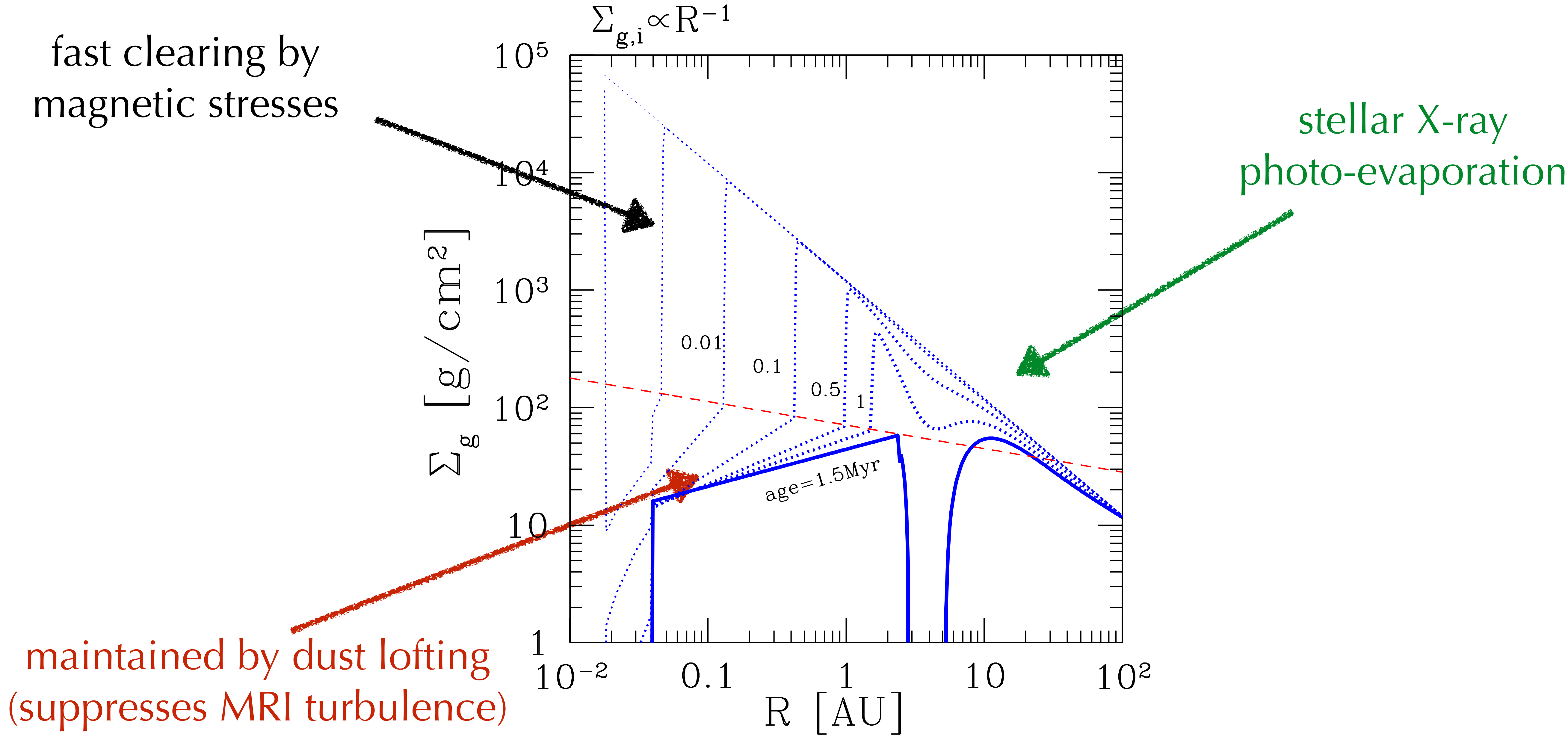




- B_r^w mixes with disk in turbulent boundary layer
- B_r is sheared into B_ϕ
- B_ϕ seeds MRI turbulence, driving accretion

$$\alpha \sim \frac{B^2}{8\pi P_g}$$

Long Term Evolution

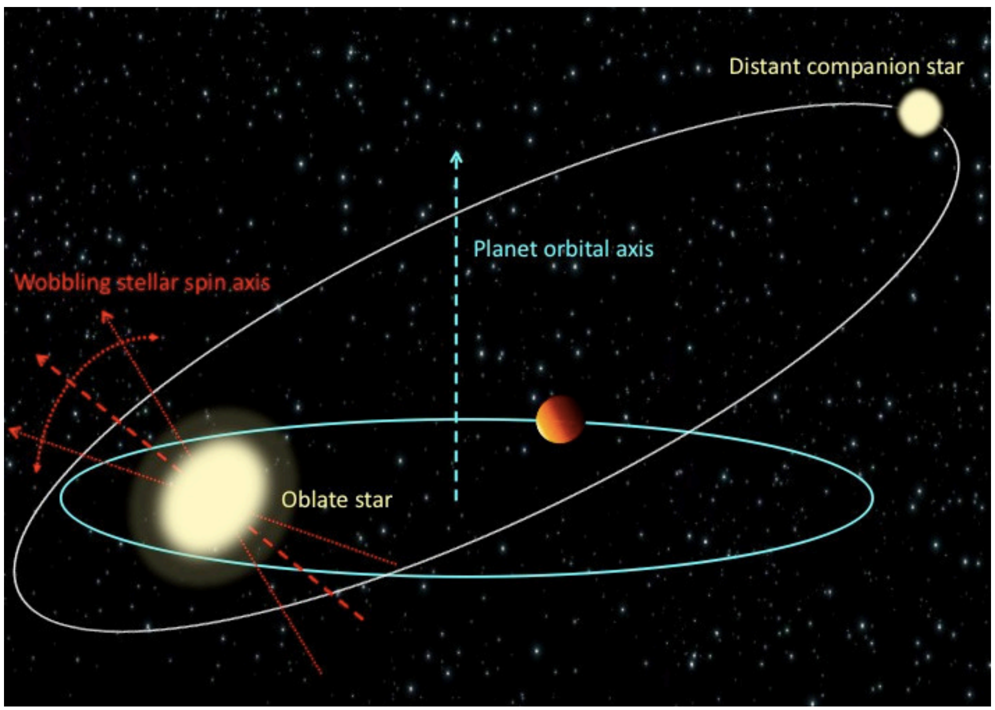


- Very low column density (slow migration)
- Remains optically thick to stellar light(small perturbation to SED)

Future:

planet-dust-MRI interaction, ring formation, dispersal-system correspondence?

Applications of the three-body problem to exoplanet systems



(credit: Dong Lai's webpage)

Cristobal Petrovich

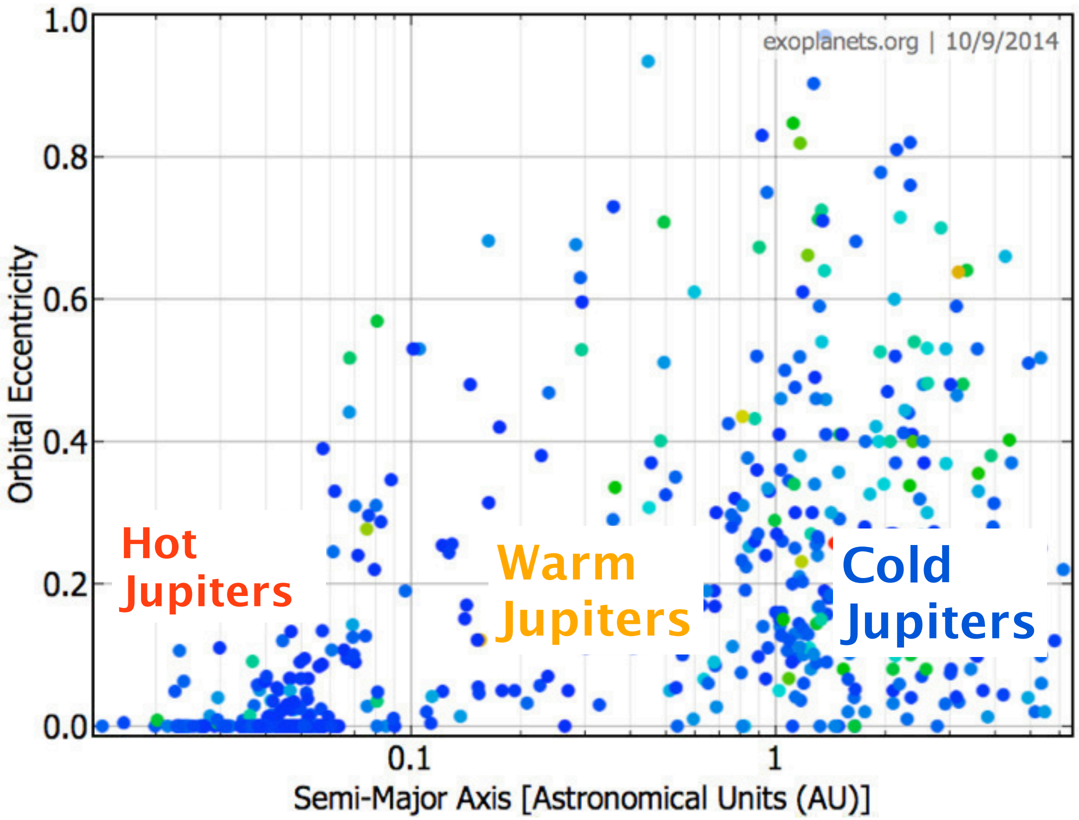
CITA Jamboree 2015
October 7, 2015

- What is the long-term evolution of planetary systems?

- Can we use the present orbital architecture of exoplanets to understand their formation?

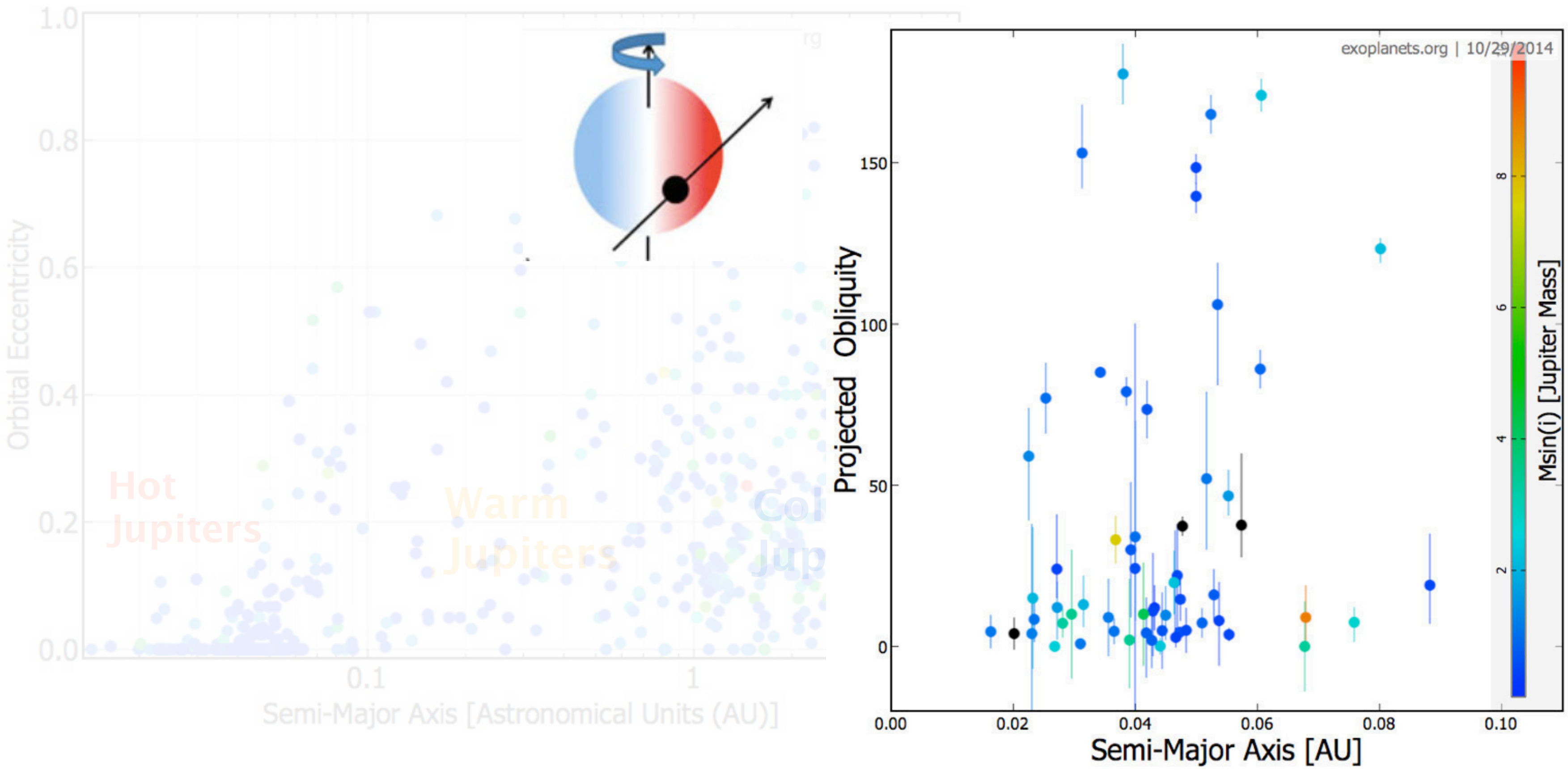
- How does stellar evolution affect the orbital architecture of exoplanets?

Gas giant exoplanets



- Period distribution?, migration of hot and warm Jupiters?
- Eccentricities of exoplanets?

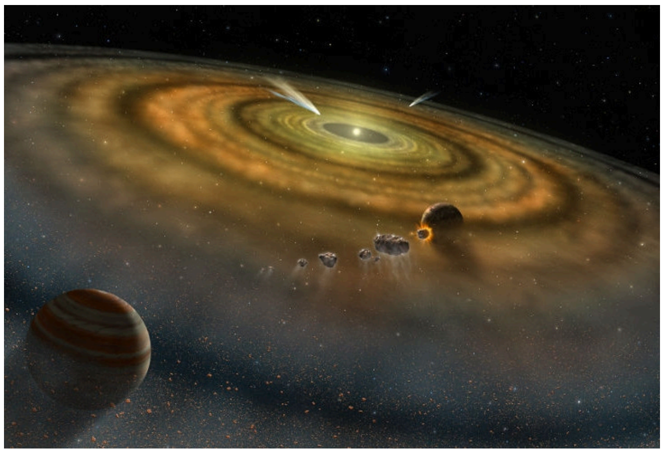
Gas giant exoplanets



- Period distribution?, migration of hot and warm Jupiters?
- Eccentricities of exoplanets?
- Stellar obliquities (spin-orbit angles)?, mutual inclinations (GAIA)?

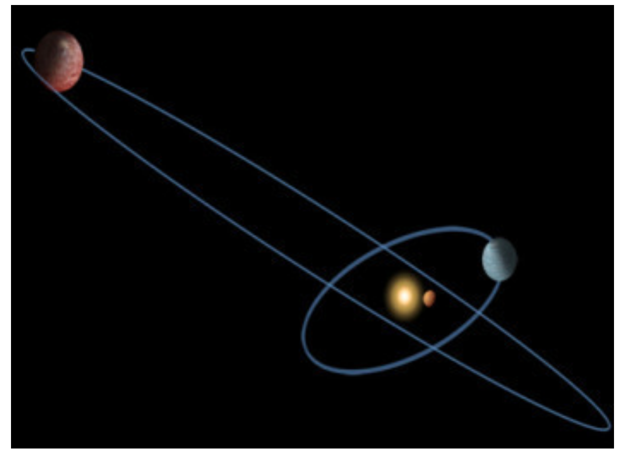
General hypothesis

$N_{pl} > 2$ Jupiters with
$a > 1$ AU, $e \sim i \sim 0$



disk dissipates

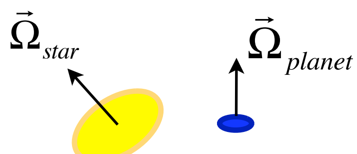
Scattering: planets lost
by ejections+collisions



dynamical relaxation

Long-term stable:
~2 well-separated planets
in hotter orbits

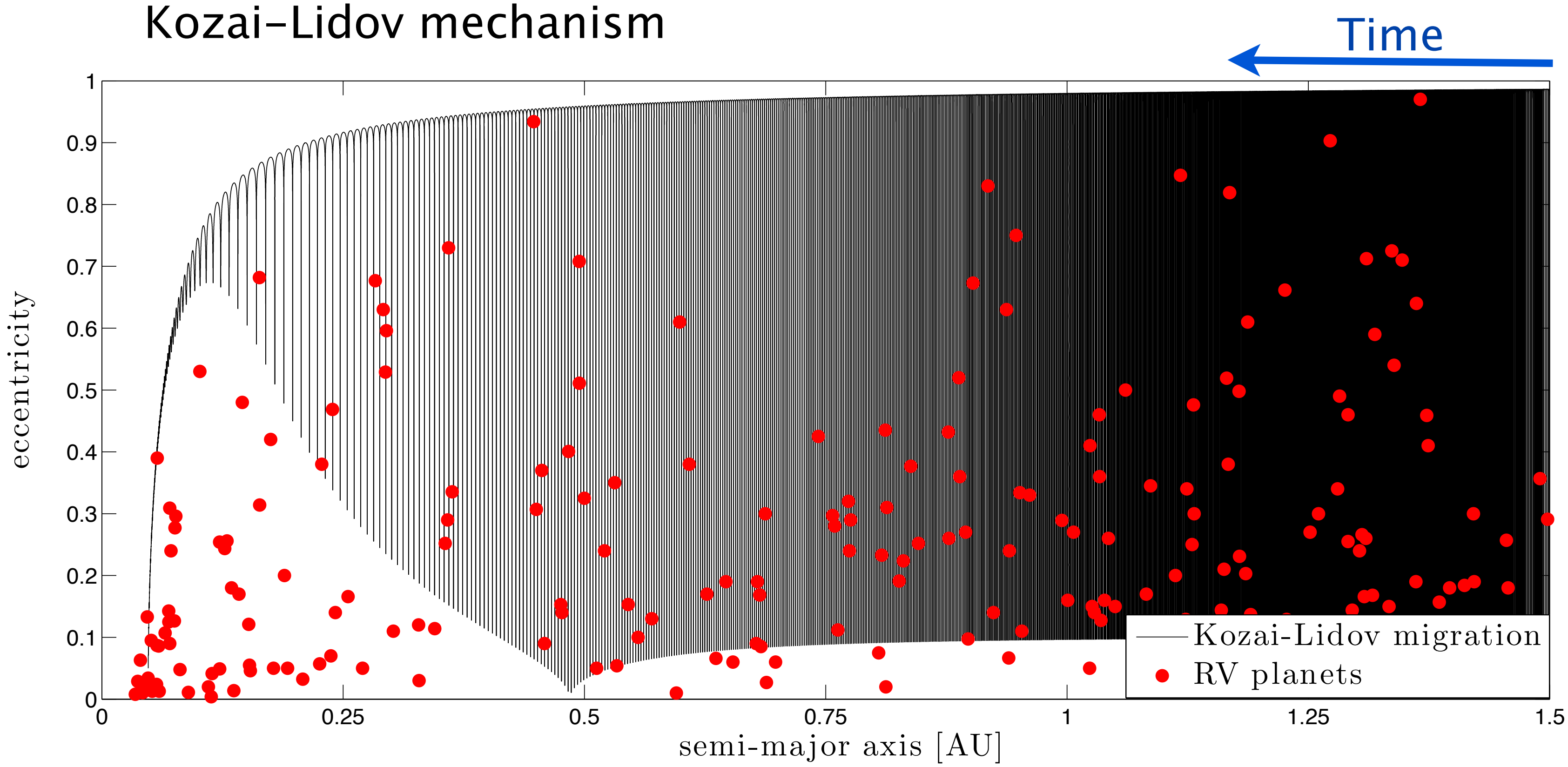
Very long-term evolution:
secular interactions, GR, tidal and
rotational bulges, tidal dissipation, etc...



Secular code in Petrovich (2015a,b)

Example: planet migration

Two well-separated planets with high mutual inclinations: Kozai-Lidov mechanism



...other applications:

- Planets in stellar binaries (e.g., Petrovich 2015a and many others)
- Various **triple systems**: tight binaries, mergers, type Ia SN by WDs head-on collisions, solar system, etc...

Influence of Atmospherical Thermal Tides on Planets' Rotation

Hanbo Wu
hwu@physics.utoronto.ca

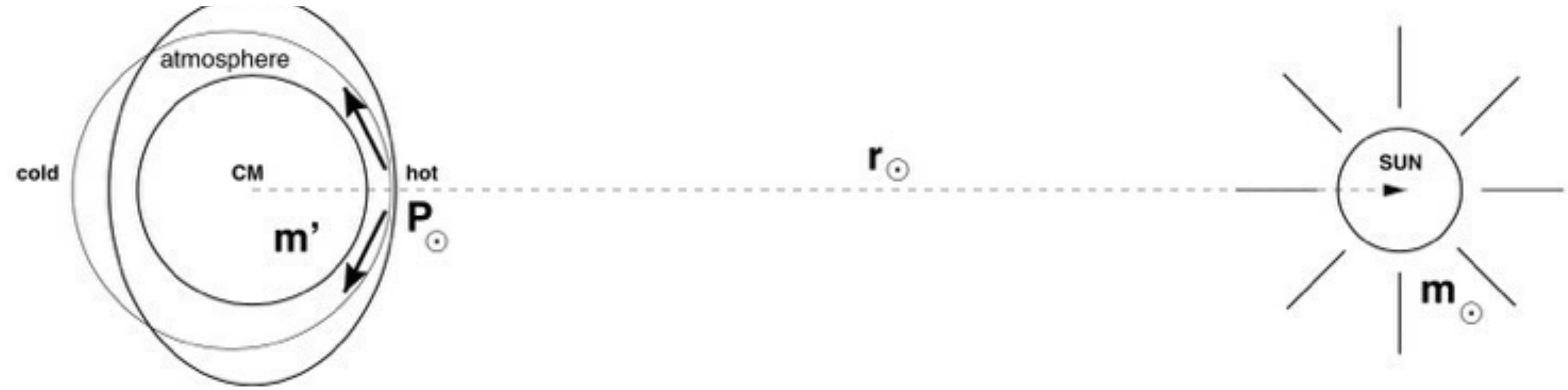


Figure 3. Thermal atmospheric tides. The atmosphere's heating decreases with the distance to the sub-solar point $P_\odot$. The atmospheric mass redistribution is essentially decomposed in a weak daily tide (round shape) and in a strong half-daily tide (oval shape).

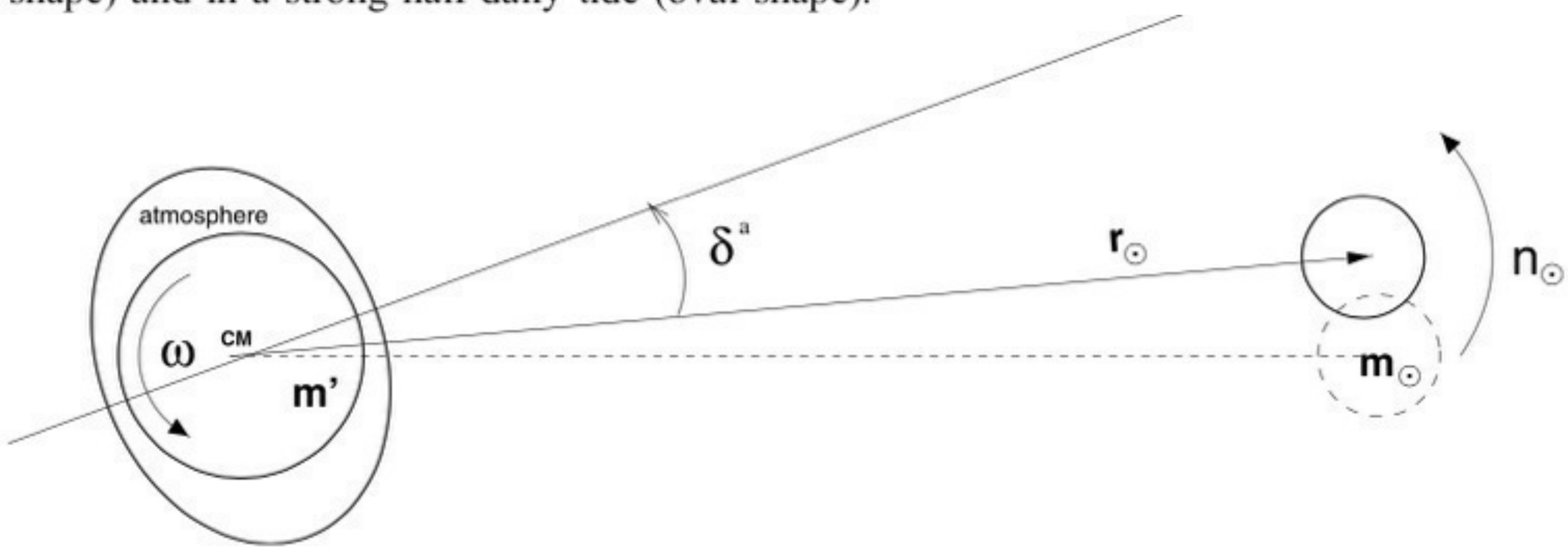
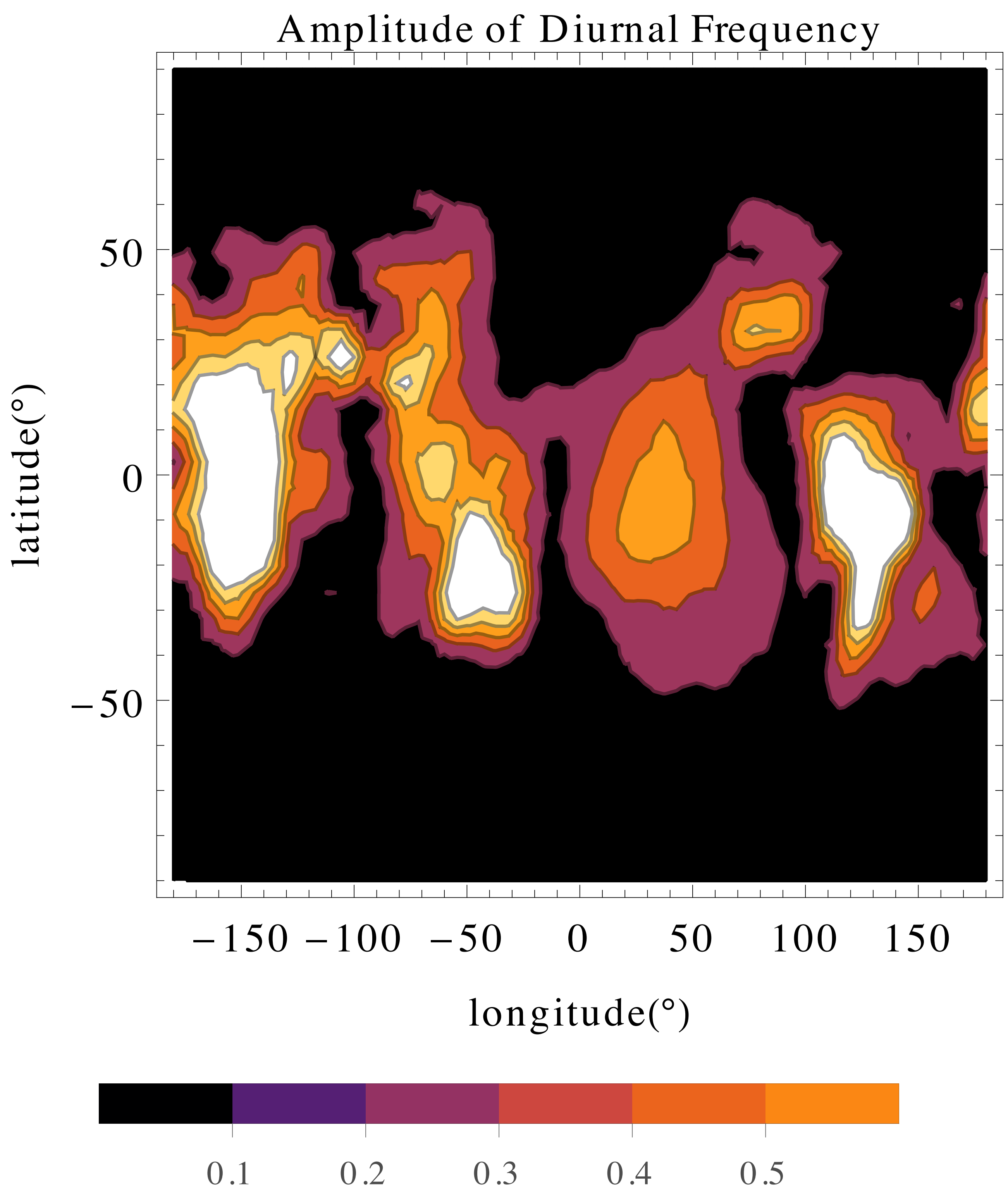


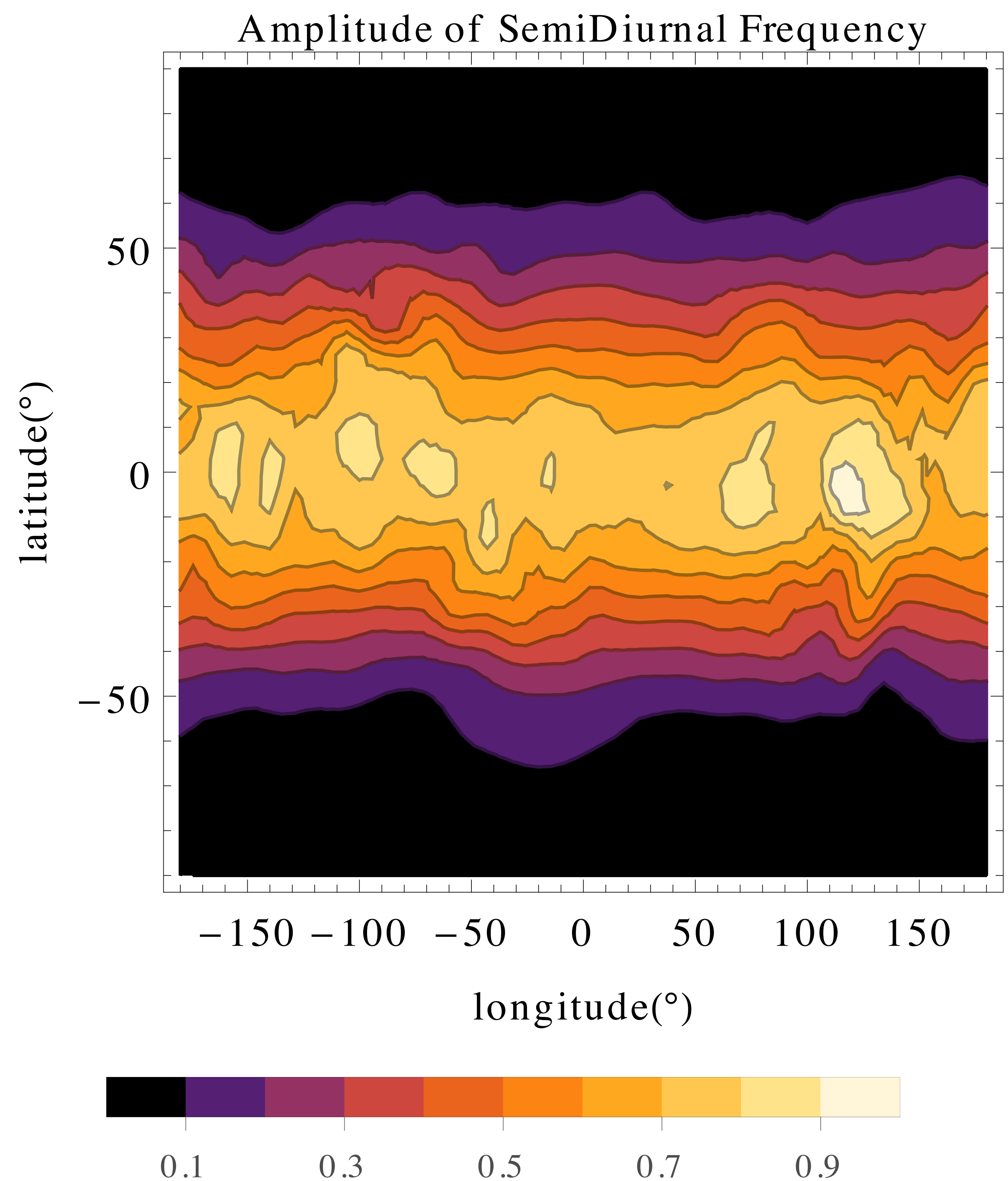
Figure 4. Phase lag for thermal atmospheric tides. During the time Δt^a the planet turns by an angle $\omega \Delta t^a$ and the Sun by $n \Delta t^a$. For $\varepsilon = 0$, the bulge phase lag is given by $\delta^a \simeq (\omega - n)\Delta t^a$.

(C. M. Corriea, 2003 [1])

With Ozone

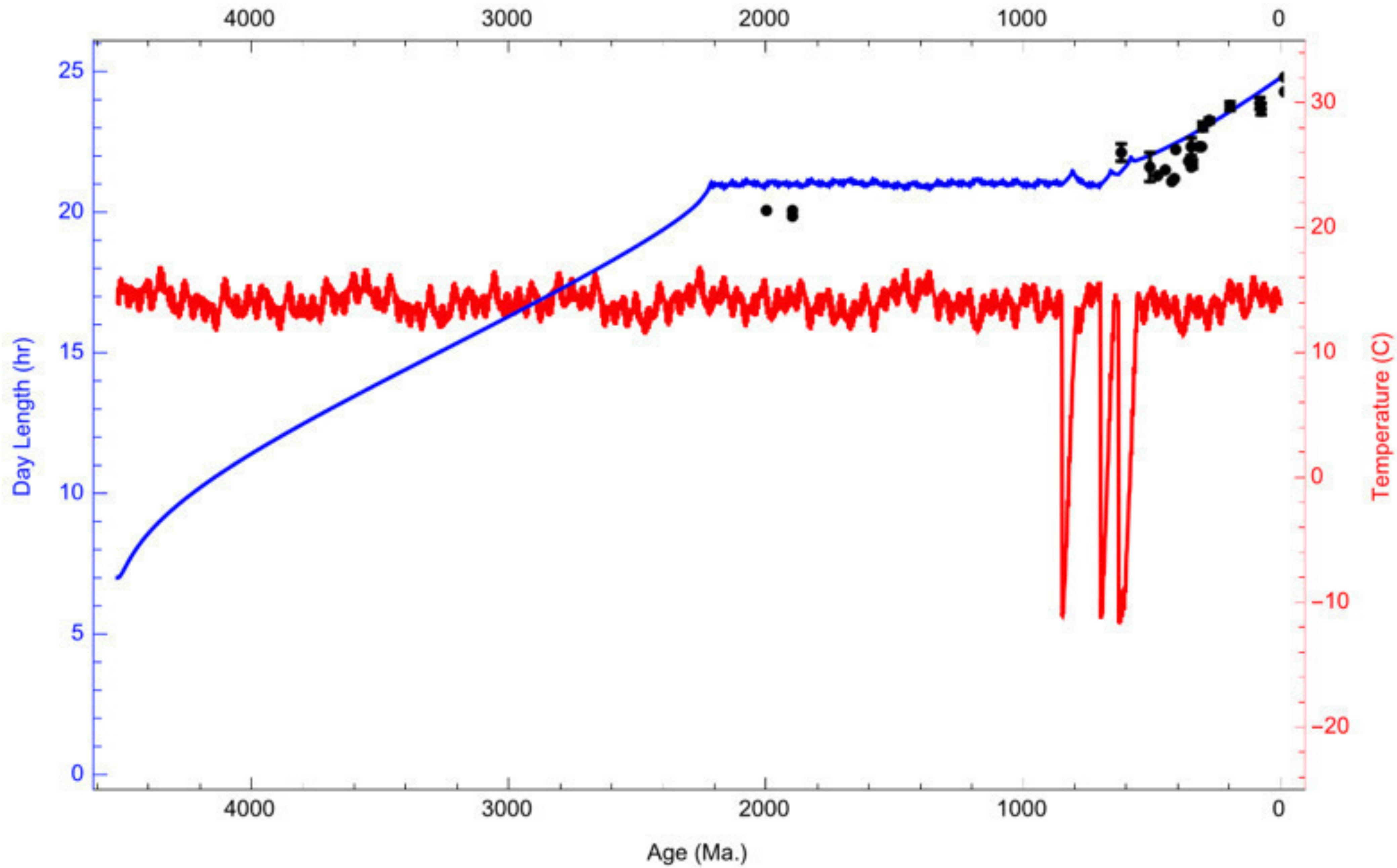


Mean Amplitude: 1.13hPa

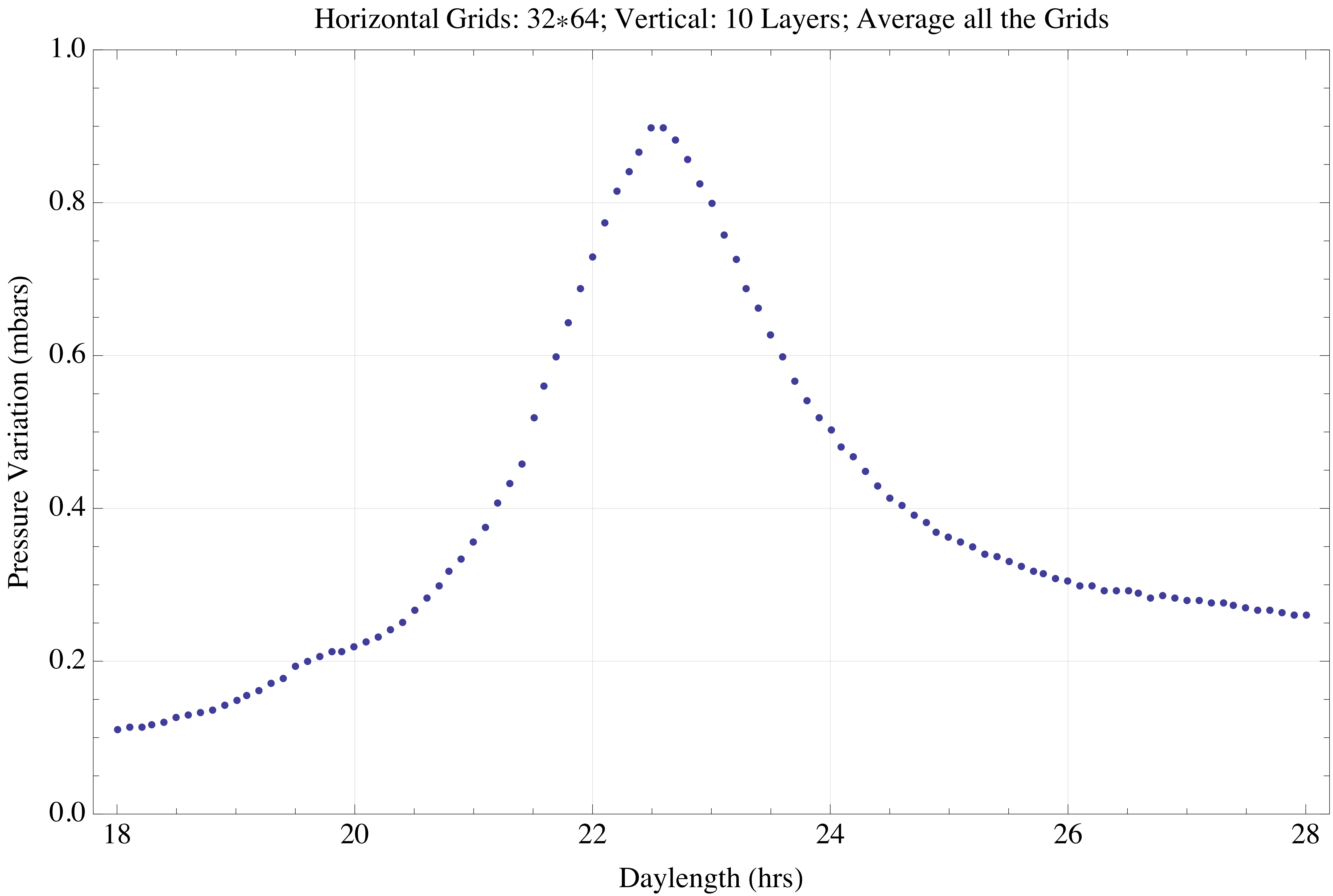


Mean Amplitude: 2.02hPa

21 h day length resonance



B. C. Barlett, D. J. Stevenson (2015)


Horizontal Grids: 32*64; Vertical: 10 Layers; Average all the Grids
Pressure Variation (mbars)
Daylength (hrs)
1.0
0.8
0.6
0.4
0.2
0.0
18
20
22
24
26
28

Thanks!

Ian Parrish

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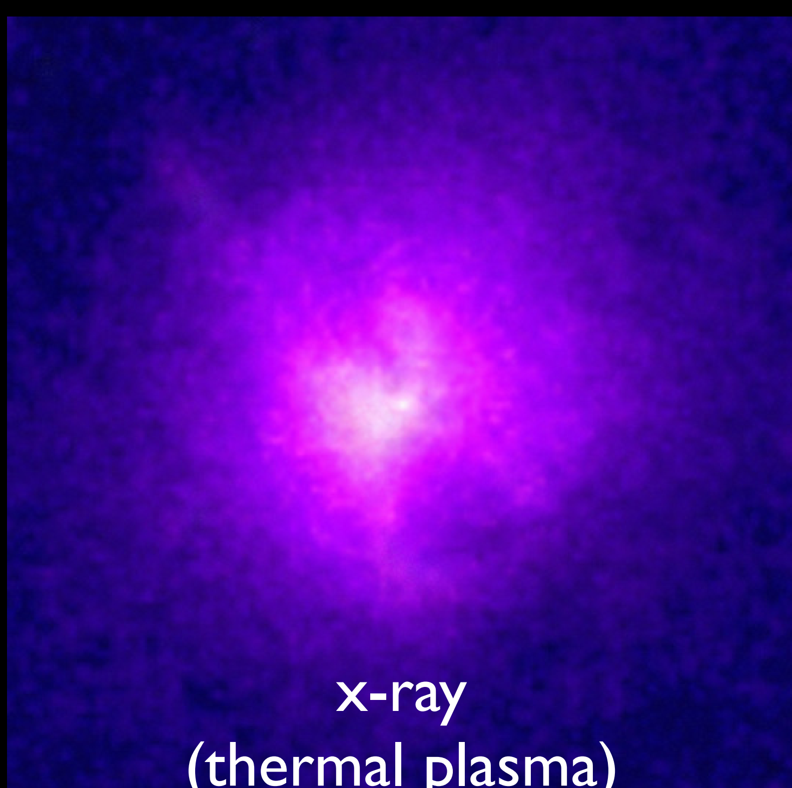
1404C

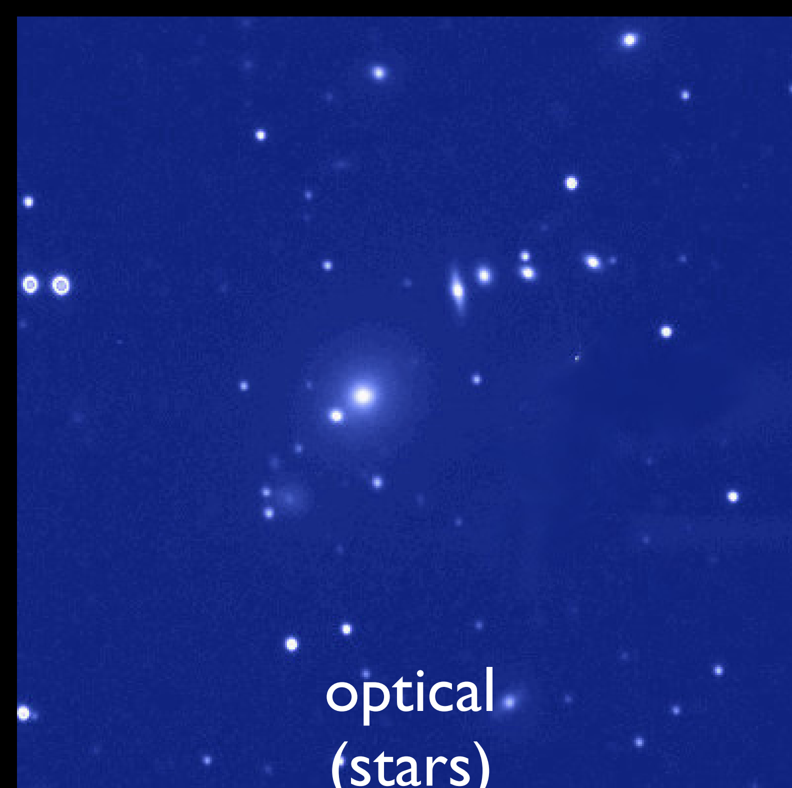
•Galaxy Groups & Clusters

- Convection and Heat Transport in the ICM
- Plasma Instabilities: MTI, HBI, viscosity, etc.
- Thermal instability: filaments, star formation
- Black hole accretion and feedback (jets/bubbles)

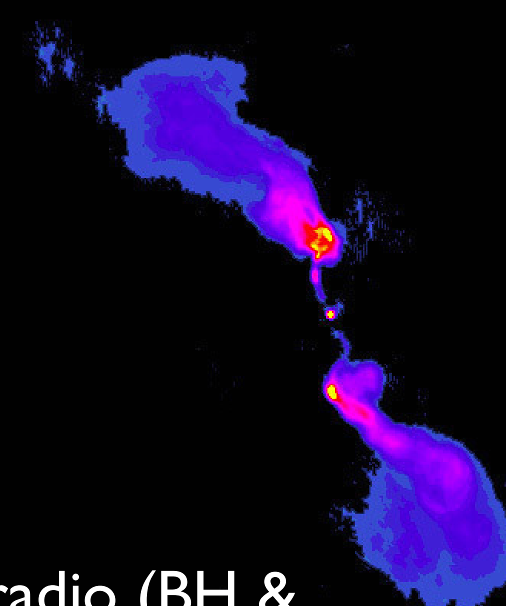


x-ray
(thermal plasma)

$\sim 0.1\ R_{\rm vir}$



optical
(stars)



radio (BH &
relativistic plasma)

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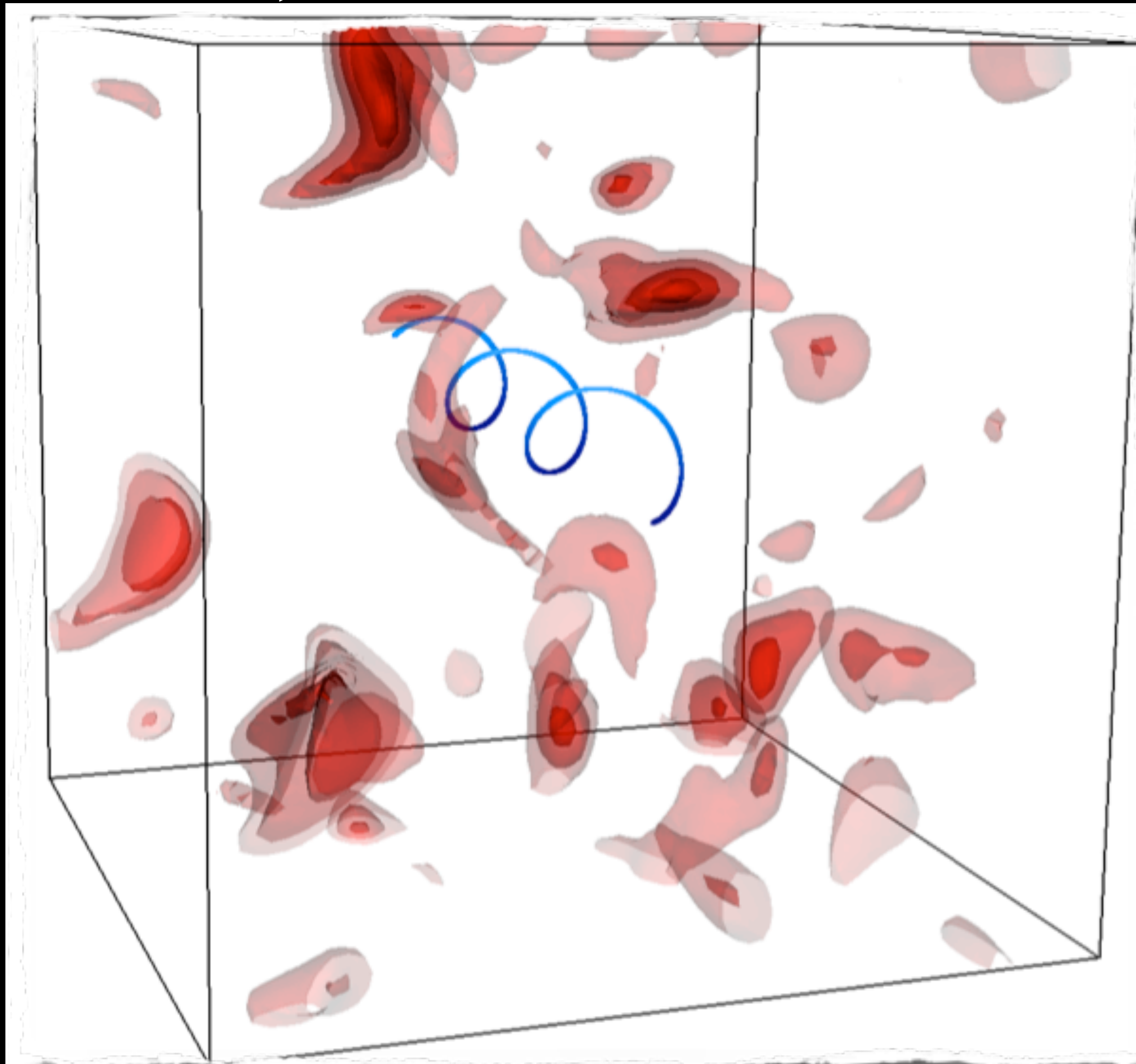
•Particle Acceleration & Heating

- Solar Wind
- MHD Turbulence (SN remnants)
- Particle Heating in MRI & BH Accretion
- Quasi-linear theory, Fermi Acceleration, Cosmic Rays



Ian Parrish

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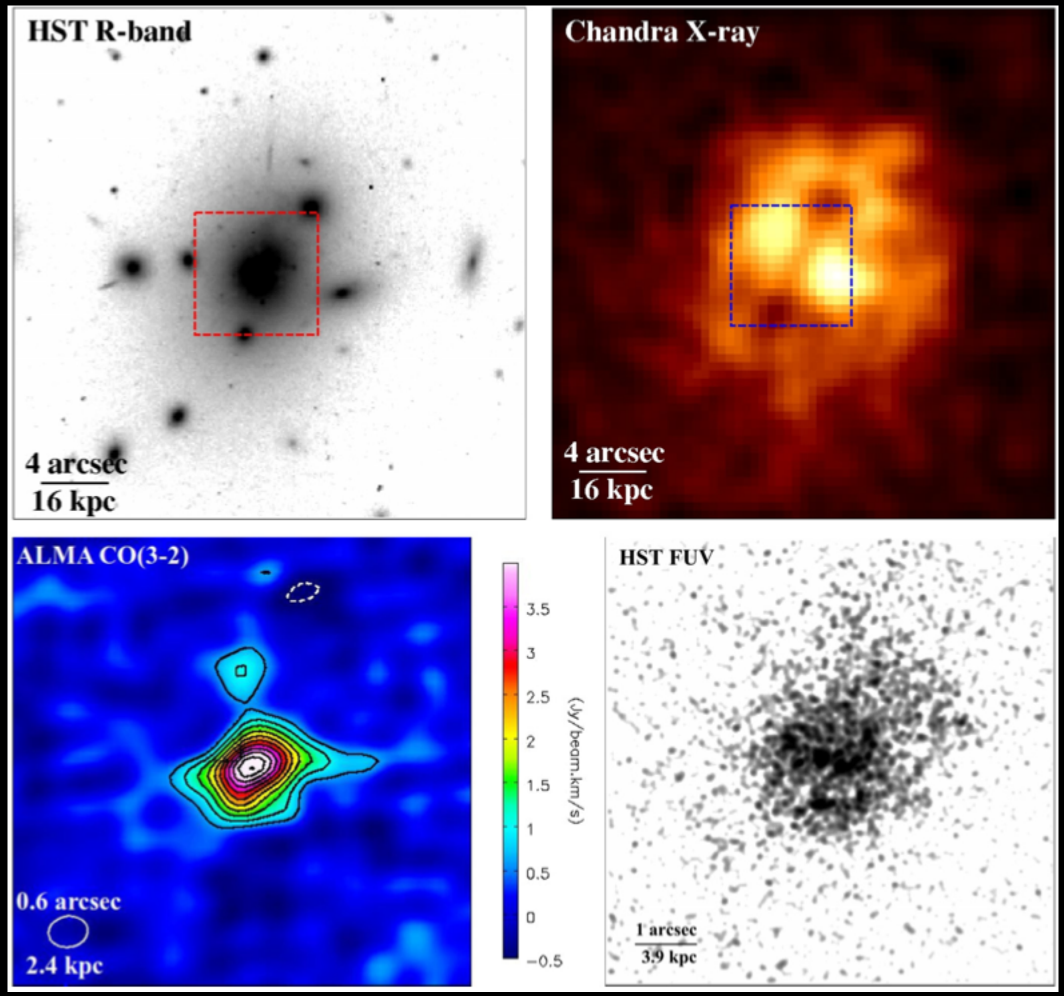
1404E

- Plasma Physics & Fusion
- High-Performance Supercomputing and GPU's with OpenACC
- Molecular Gas in Galaxy Clusters with Norm and Brian McNamara



(McNamara++ 2014)

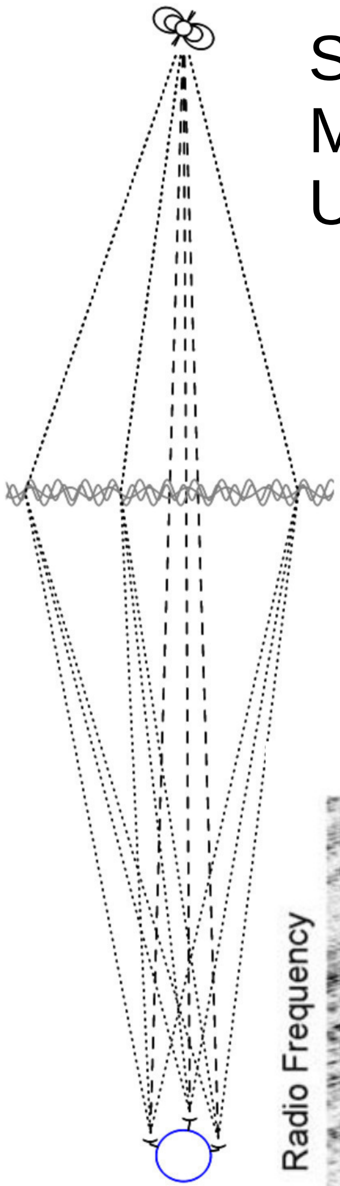
Abell 1835

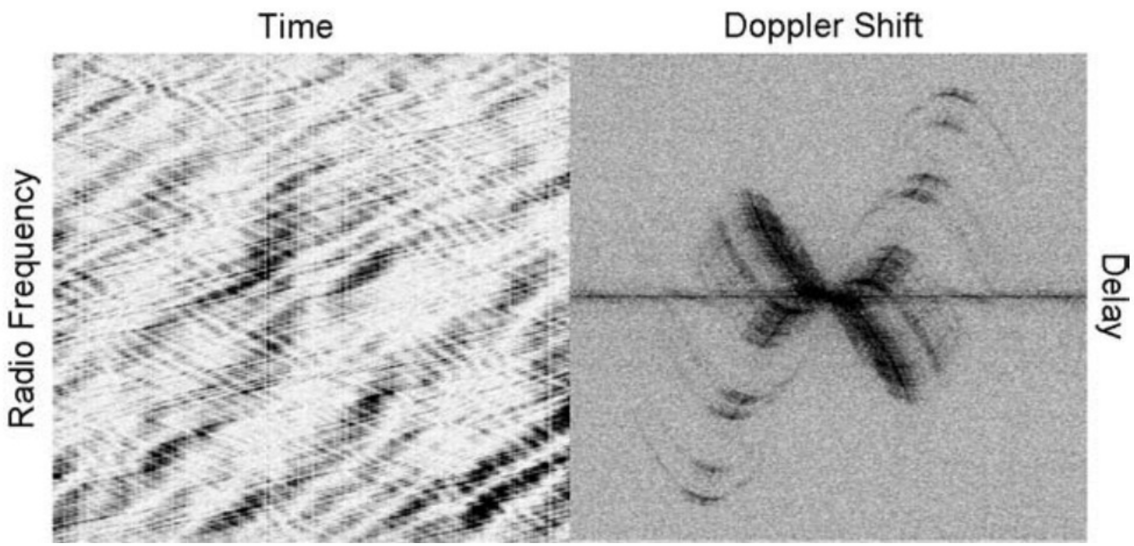
Figure from Batygin & Stevenson 2010

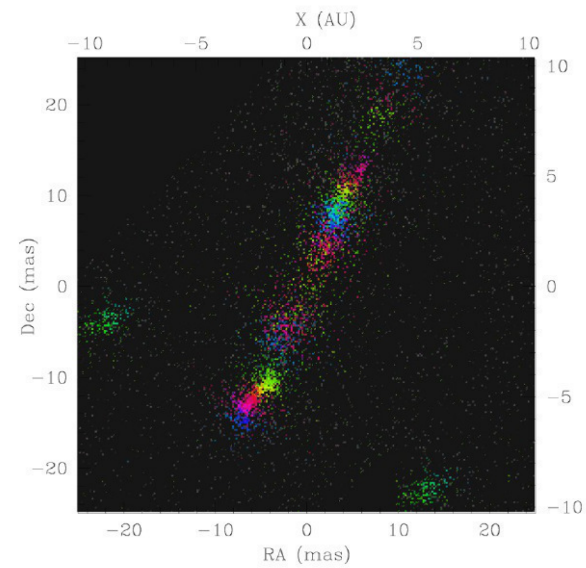
Robert Main

Probing fundamental physics of pulsars using scintillometry

Supervisors:
Marten van Kerkwijk &
Ue-Li Pen







Rotation in red giants and magnetism in white dwarfs

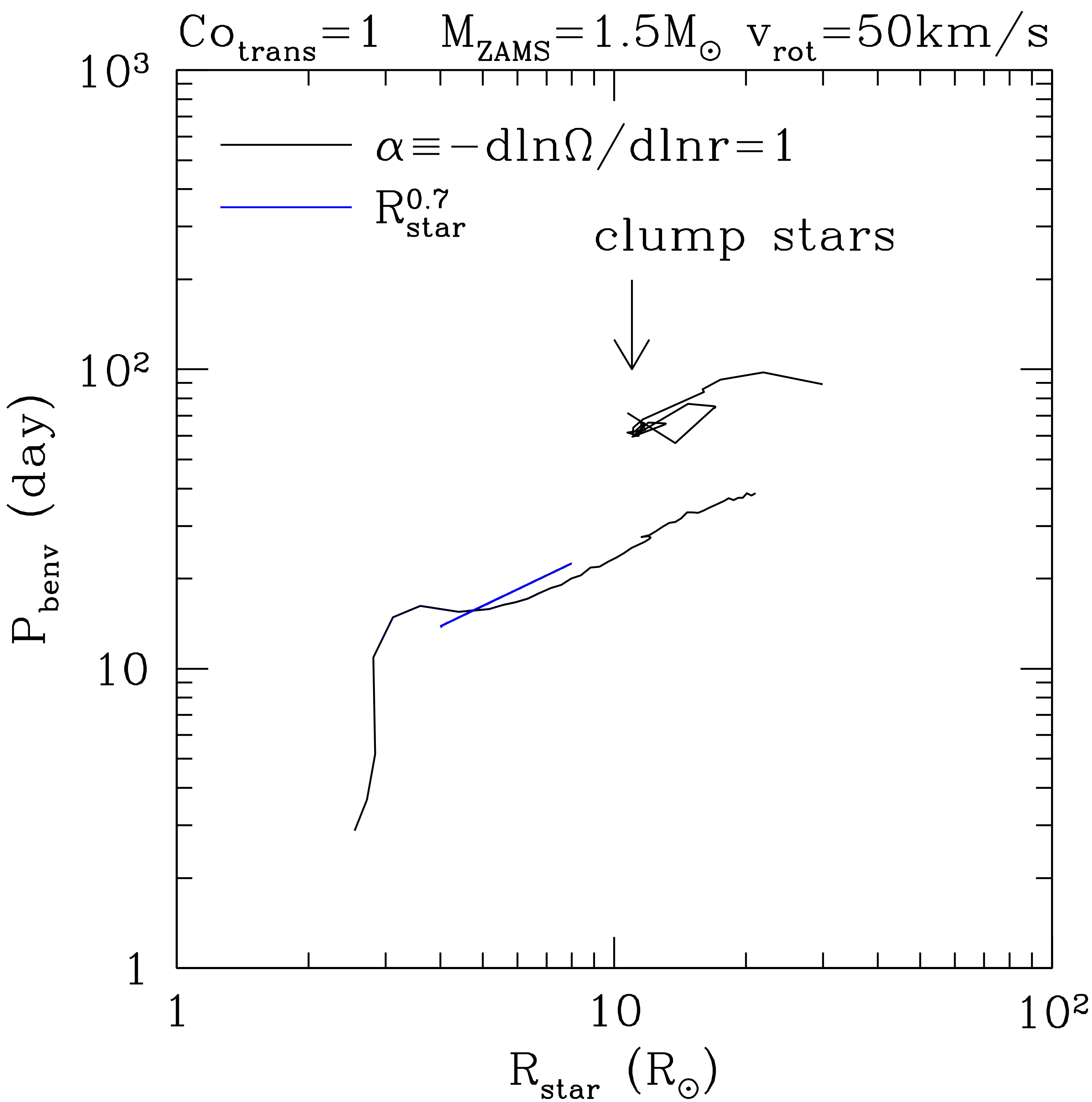
Yevgeni Kissin
&
Chris Thompson

CITA Jamboree - October 7, 2015

Rotation in red giants

- Geometrically thick convection zone
- Angular momentum pumping
  - $\Omega \propto r^{-2}$
- Very fast rotation ($\mathrm{Co}_{\mathrm{base\ envelope}} \geq 1$)
  - $\Omega \propto r^{-1}$

Rotation in red giants

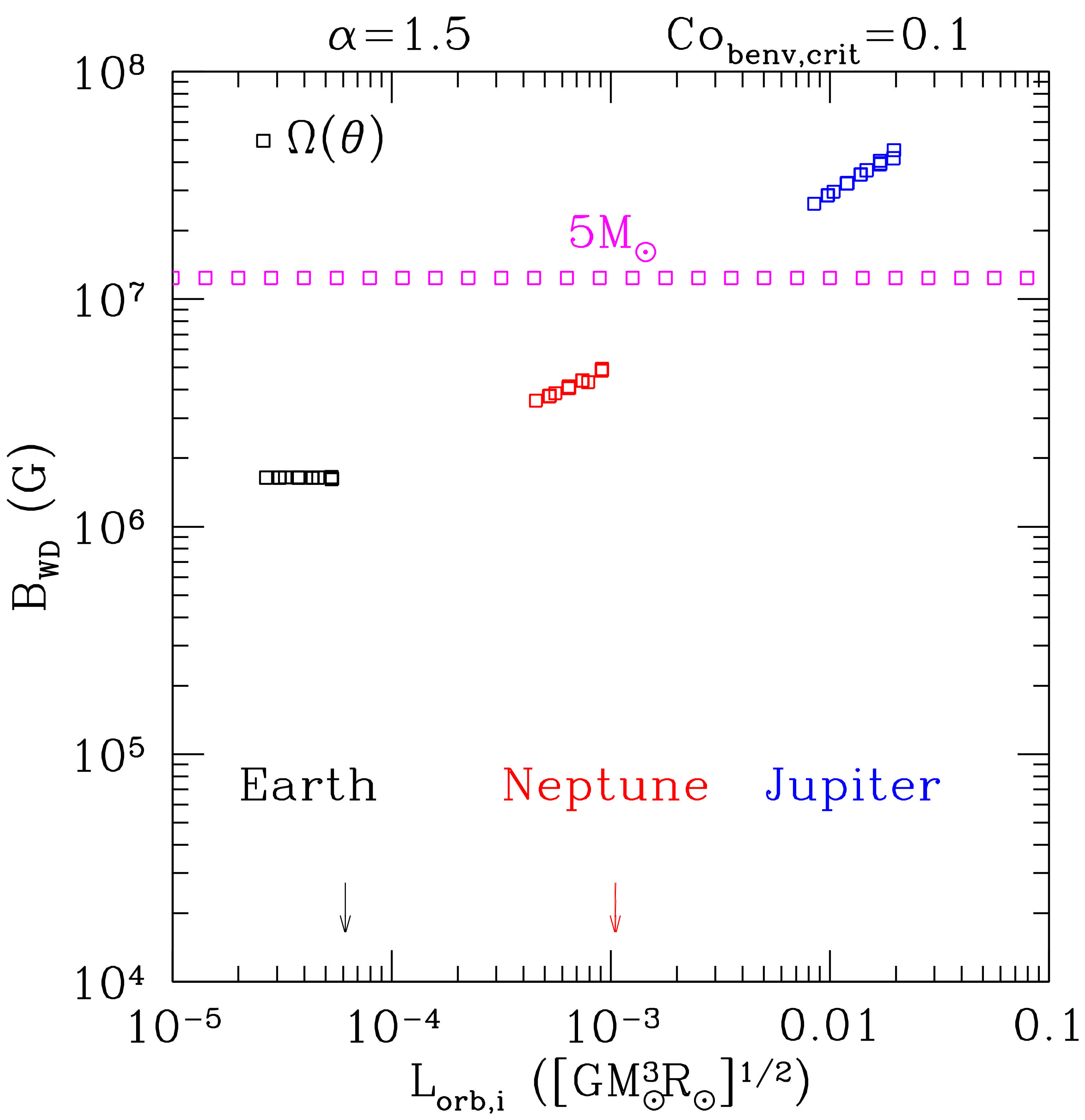


ApJ publication
2015ApJ...808...35K

Magnetism in white dwarfs

- Latitudinal rotation gradients
- Deposit of magnetized material in core

Magnetism in white dwarfs



ApJ publication
2015ApJ...809..108K