

MAGNETISMO CÓSMICO



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UFES, 9 de Outubro 2018



magnetismo e um fenomeno muito conhecido por nos



Por exemplo, os imas tem a propriedade de atrair os metais

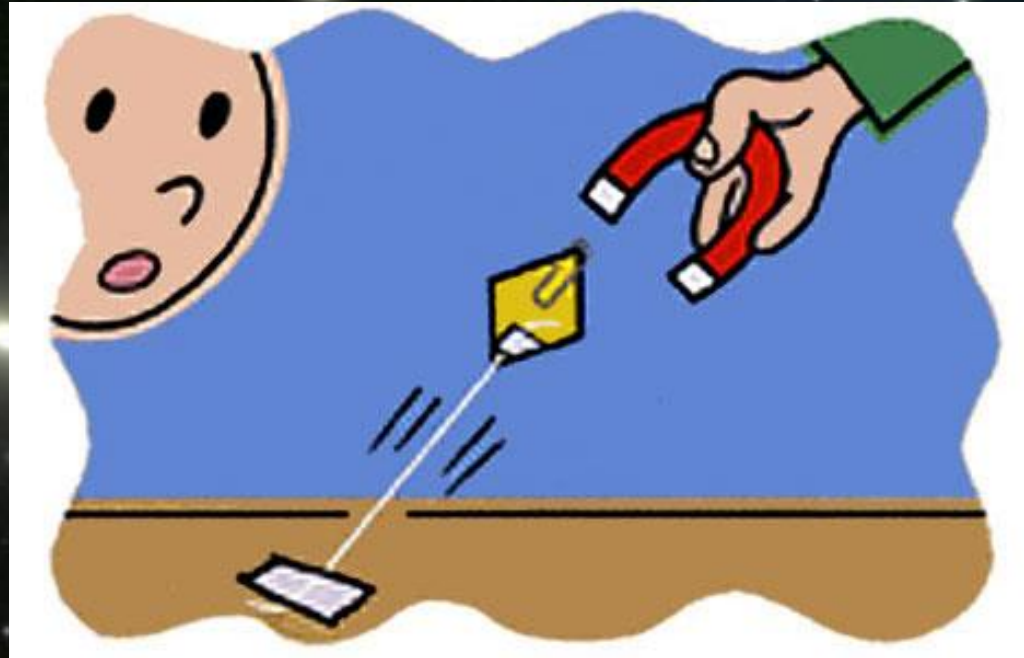
Bussola: agulha imantada que aponta sempre para o Norte!

***Magnetismo conhecido
desde a Grecia antiga***



pedra magnetita
IMA Natural

O Que é o Magnetismo ?



E um fenómeno físico produzido pelo **movimento de cargas eléctricas**, que resulta em forças atrativas e repulsivas entre os objetos: **Forças Magneticas!**

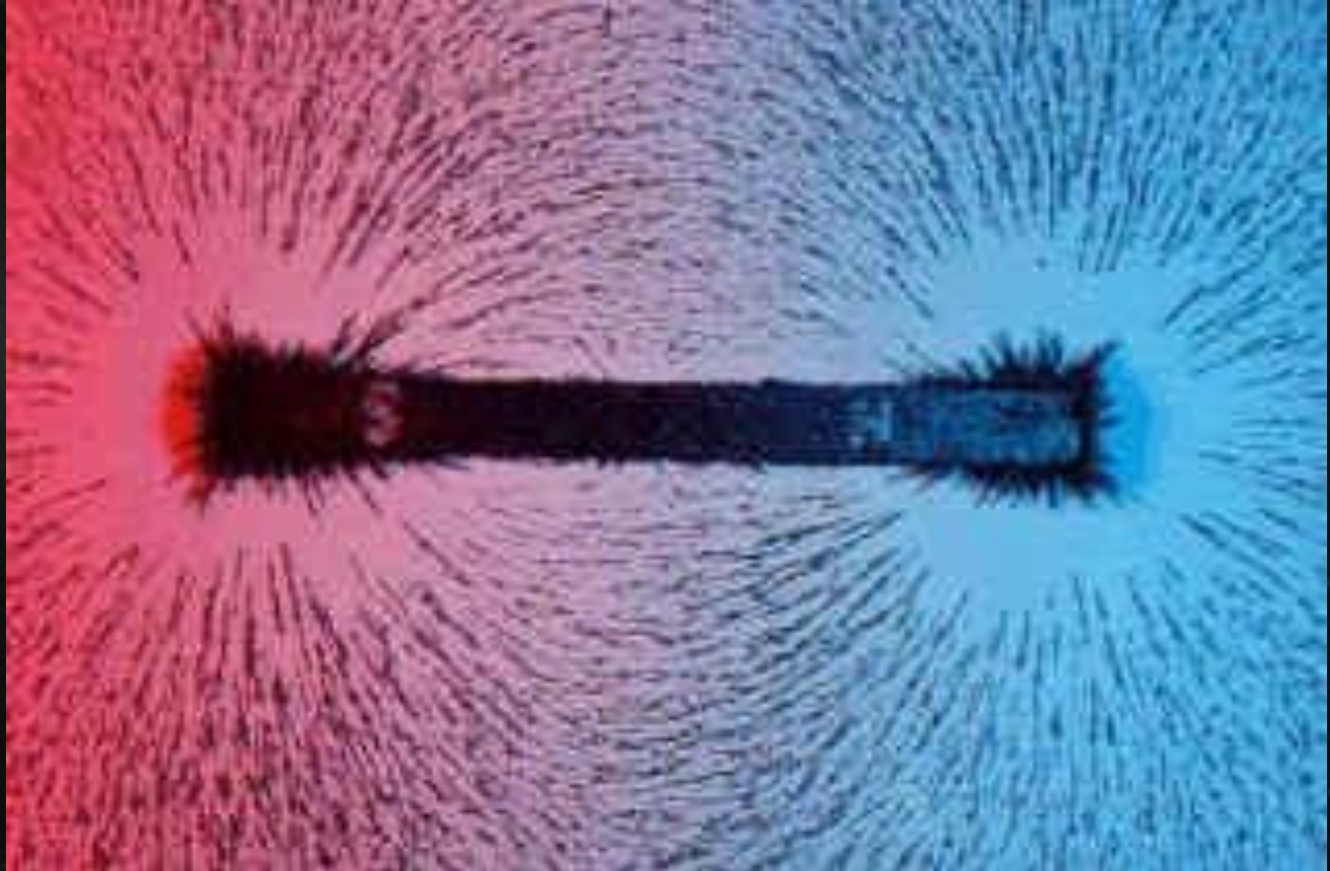
O que é Magnetismo ?



Campo magnético gerado por um ímã em forma de barra e em forma de ferradura.

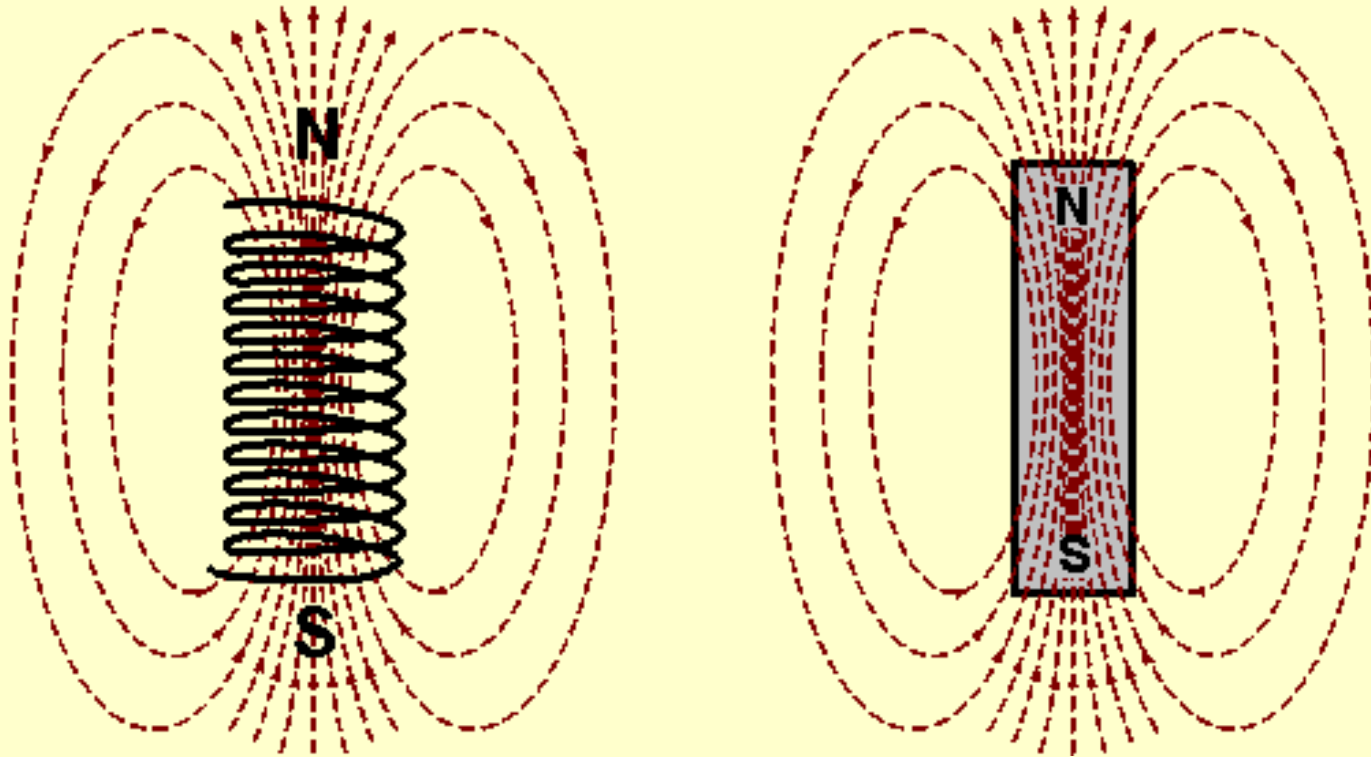
o fenómeno do magnetismo é "mediado" pelo campo magnético.

O que é Magnetismo ?



O fenómeno do magnetismo é "mediado" pelo campo magnético.

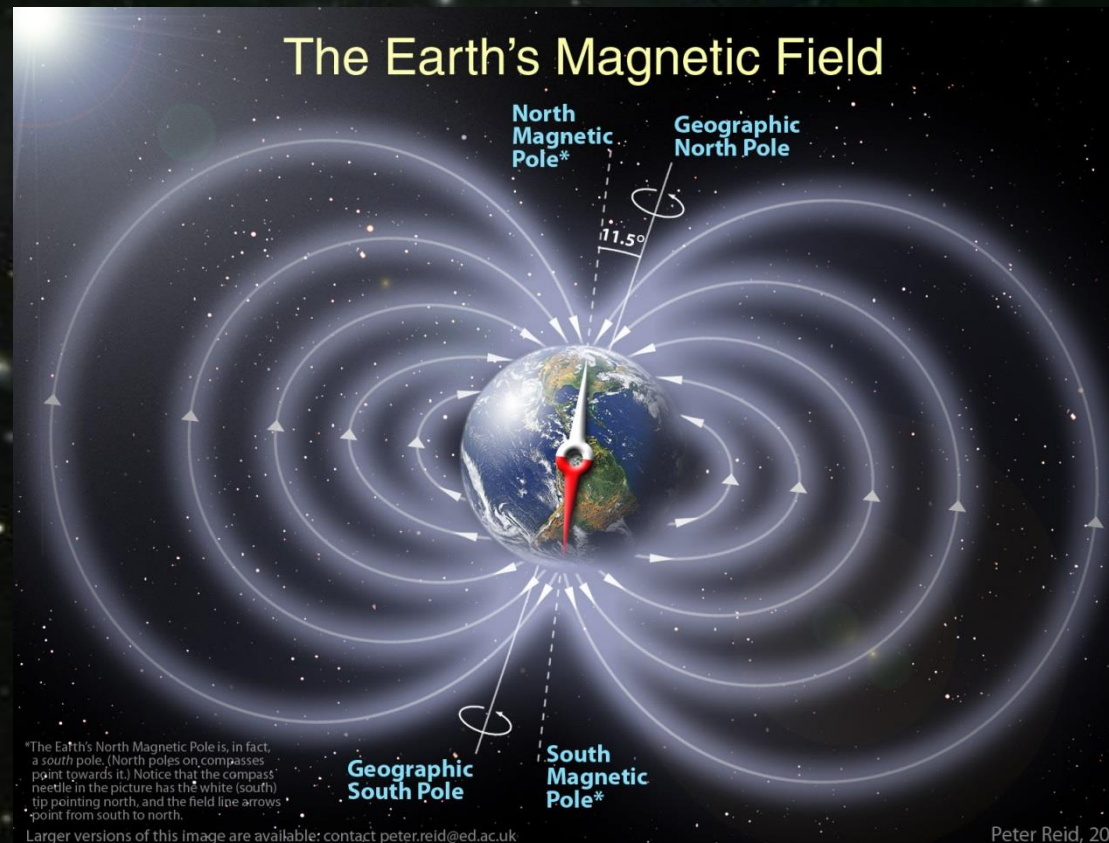
O que é Magnetismo ?



***corrente elétrica através do fio metálico
produz campo magnético igual ao ímã***

Terra: Ima gigante

1600: William Gilbert, médico da rainha Elisabete I, estudou a inclinacao da agulha magnética da bussola e chegou `a conclusao que "a Tierra e' um ima gigante"



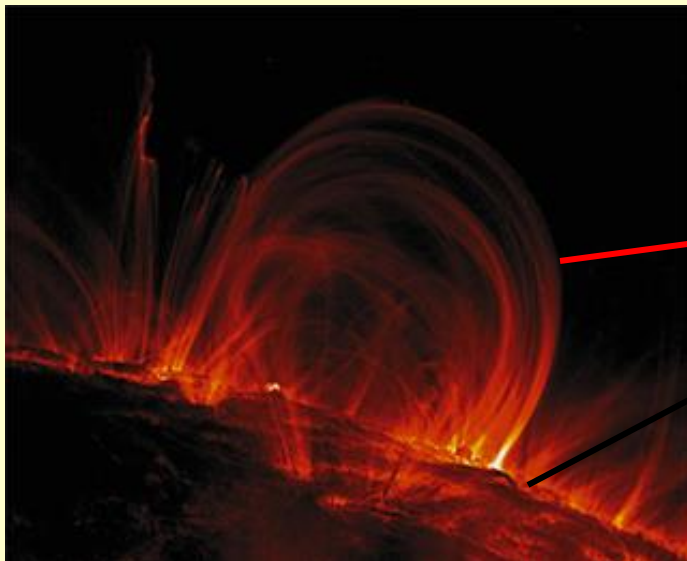
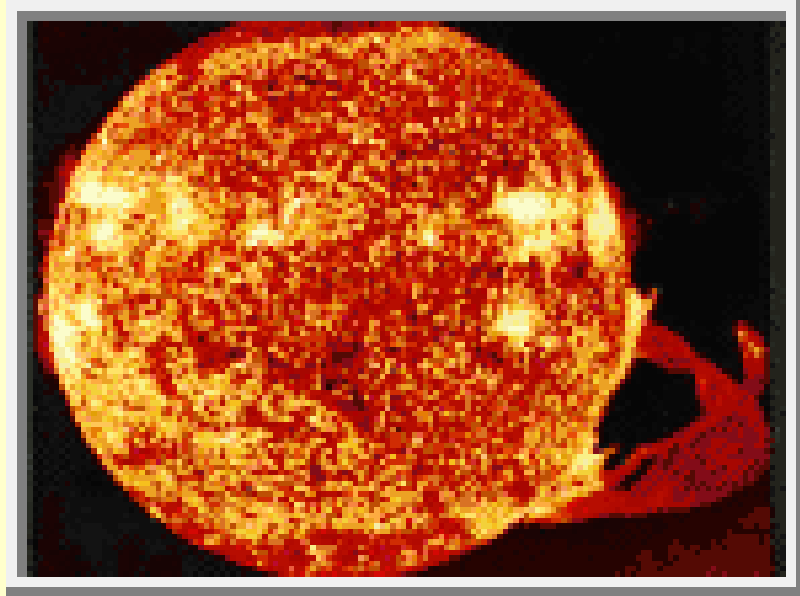
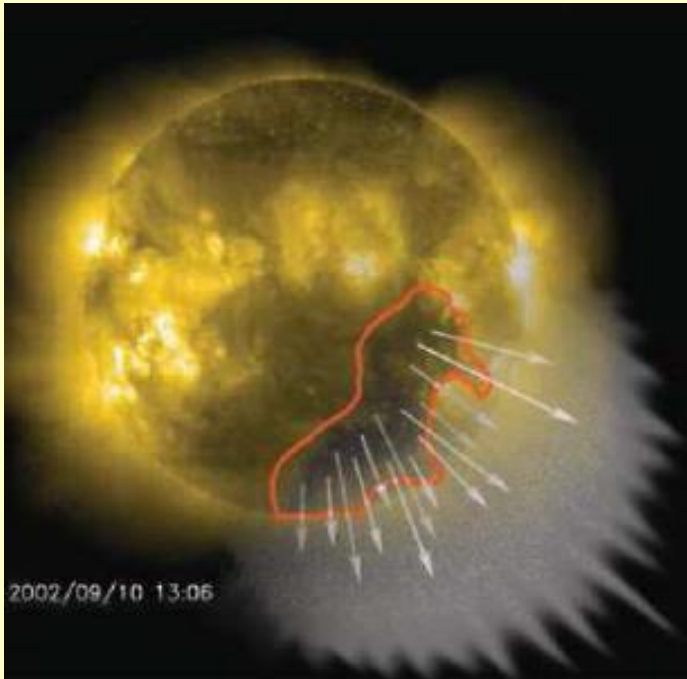
**Mais de 90% da materia
visivel no Universo:**

**fluido de cargas em
movimento com campos
magneticos**

=

PLASMA

CAMPOS MAGNÉTICOS NO SOL



Sol: fluido condutor (PLASMA)

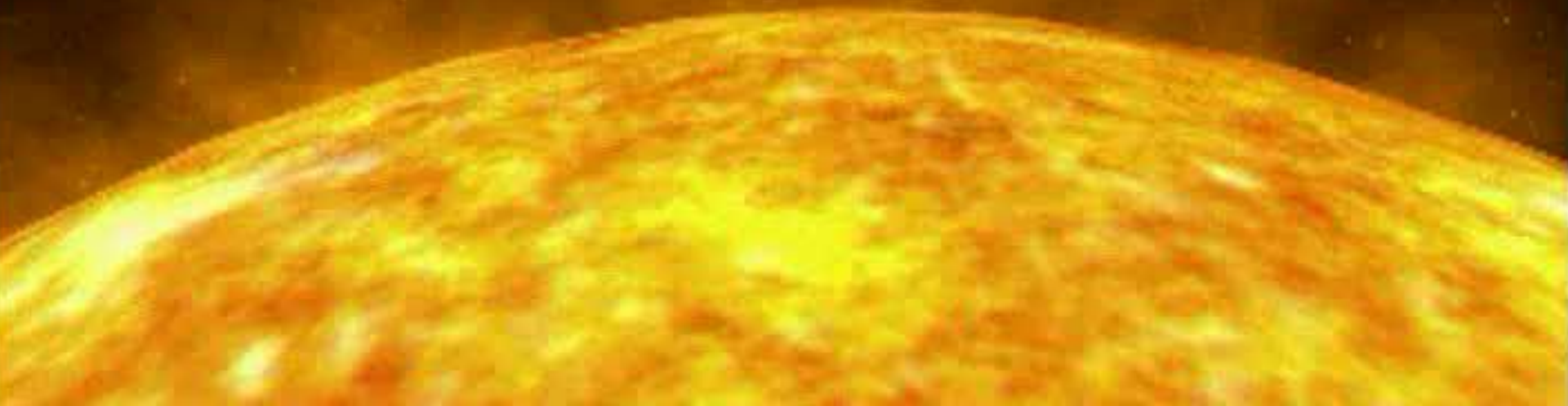
Na coroa (2×10^6 graus Celcius):

arcos magnéticos (30.000-100.000 km)

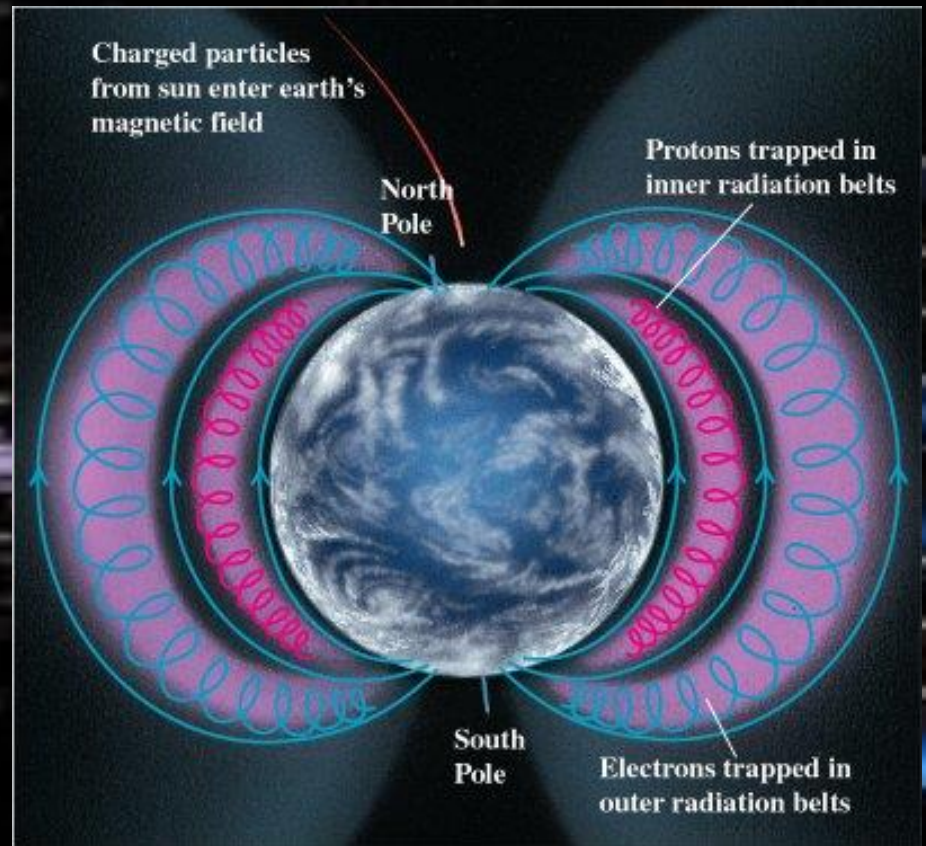
Manchas Solares:

$B = 500-4000$ vezes B_{Terra}

Sol eTerra



Sol e Terra

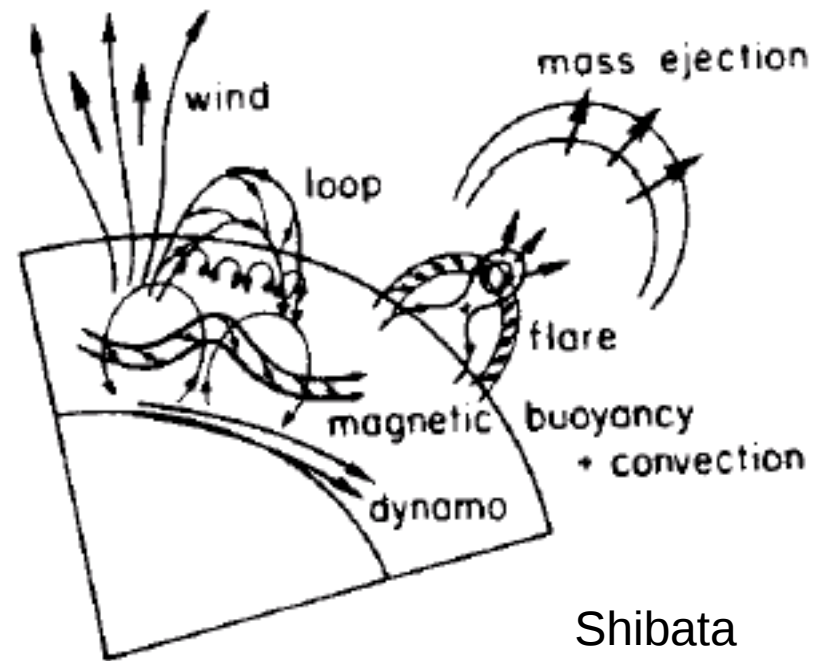
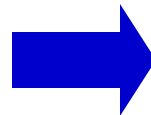
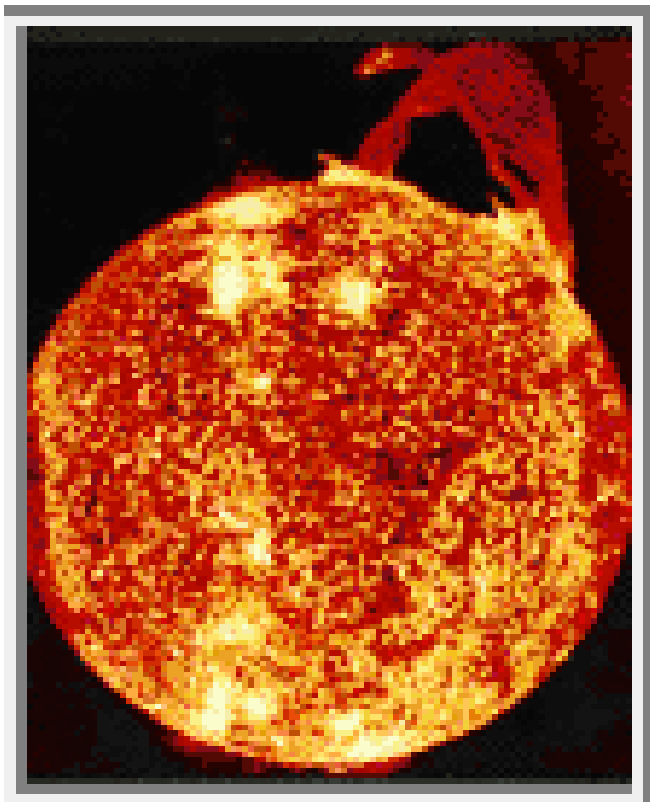


Qual a origem do campo magnético no Sol ?

Dínamo



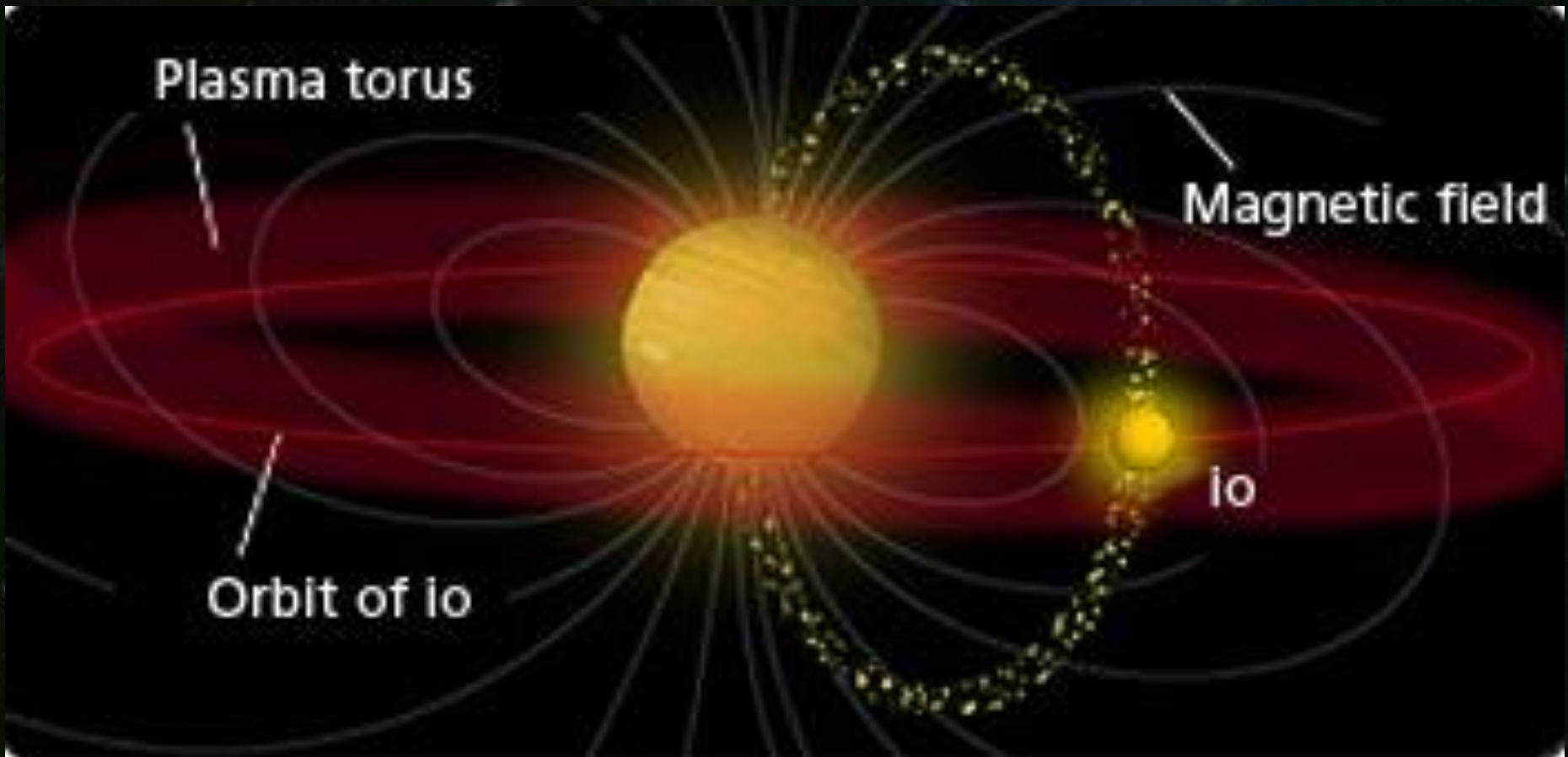
Dinamo: Rotacao + Conveccao do fluido carregado



Shibata
2005

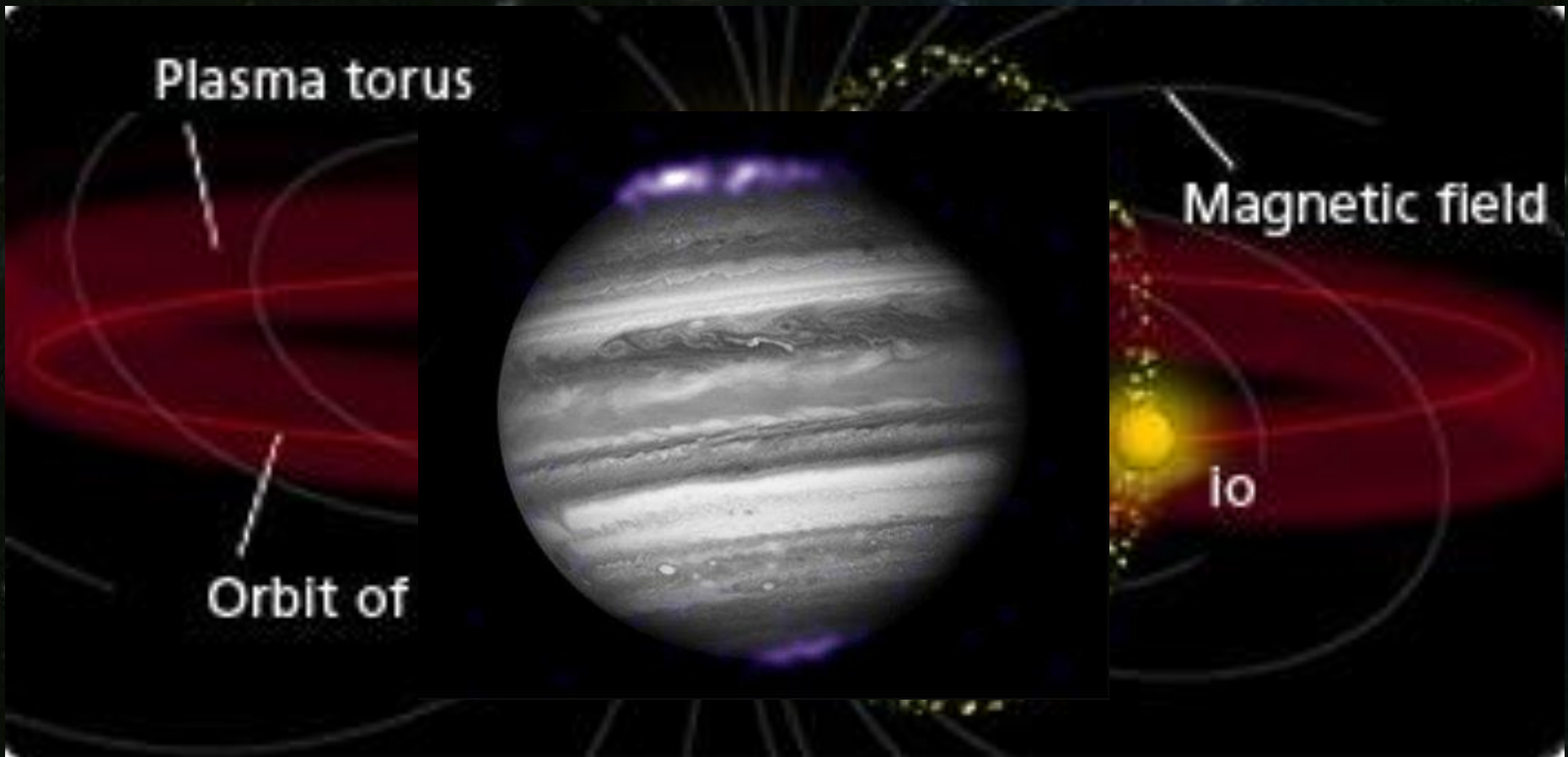
(stars)

Campos magnéticos em outros planetas



JUPITER

Campos magnéticos em outros planetas



JUPITER

Campos magnéticos em estrelas moribundas

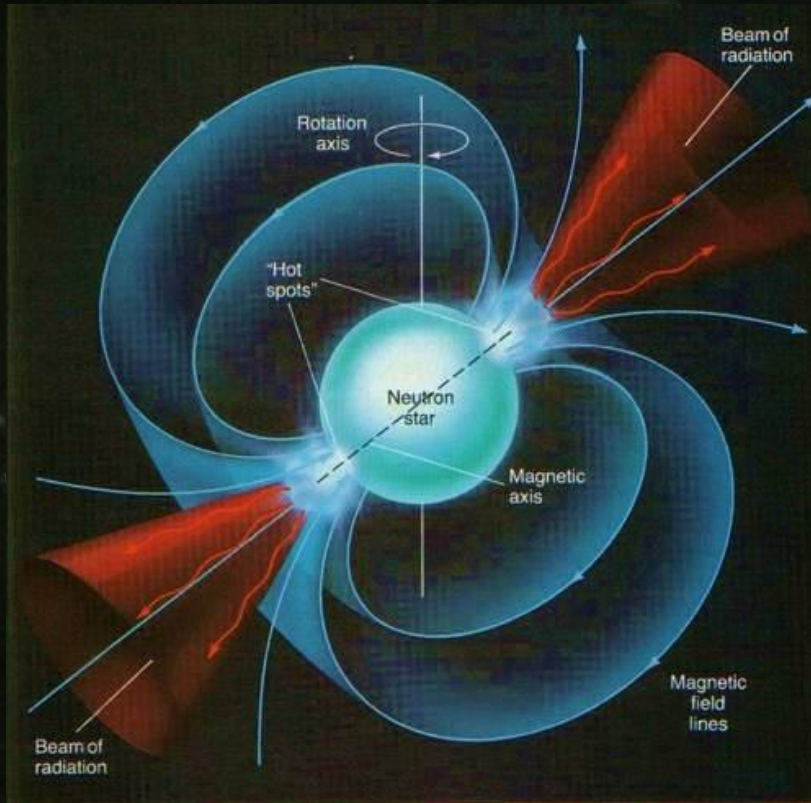


Pulsar



Ana Branca: o Sol de amanhã

Campos magnéticos em estrelas moribundas

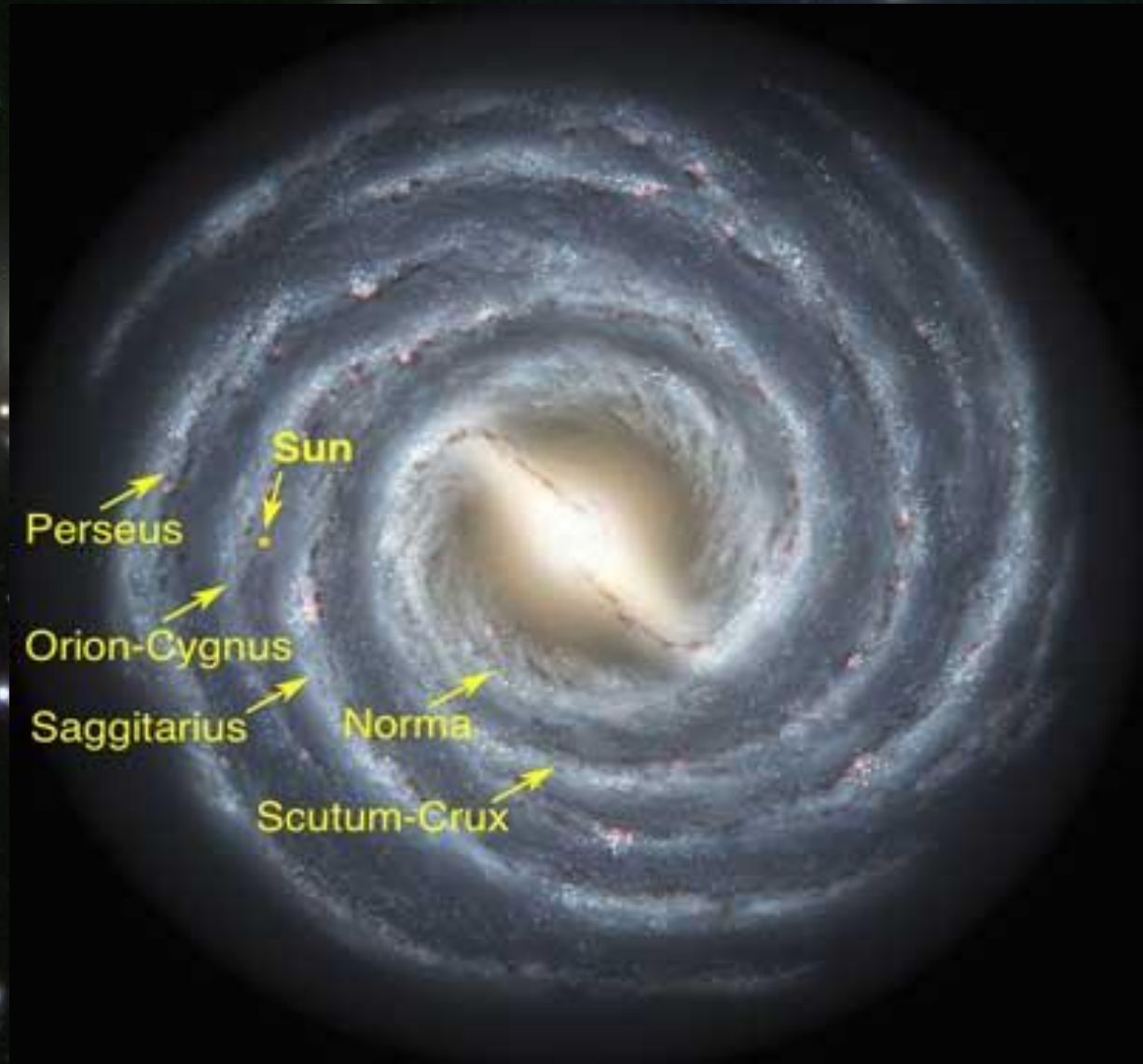


Pulsar

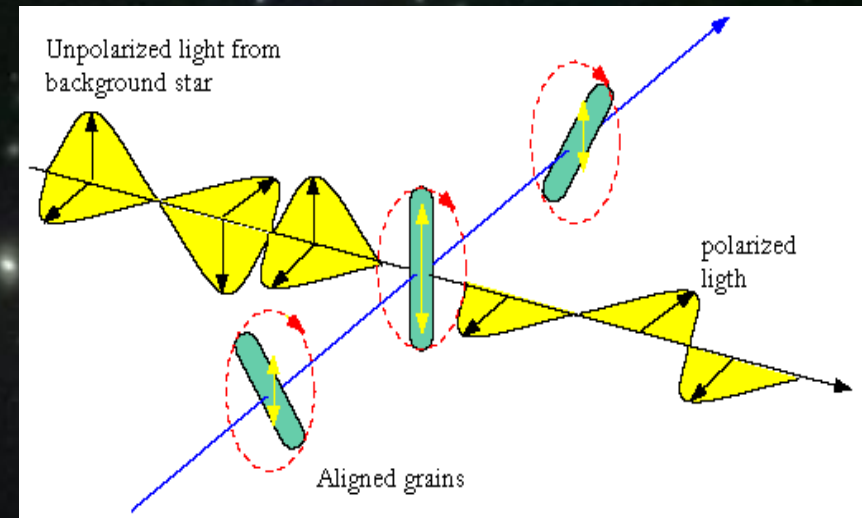
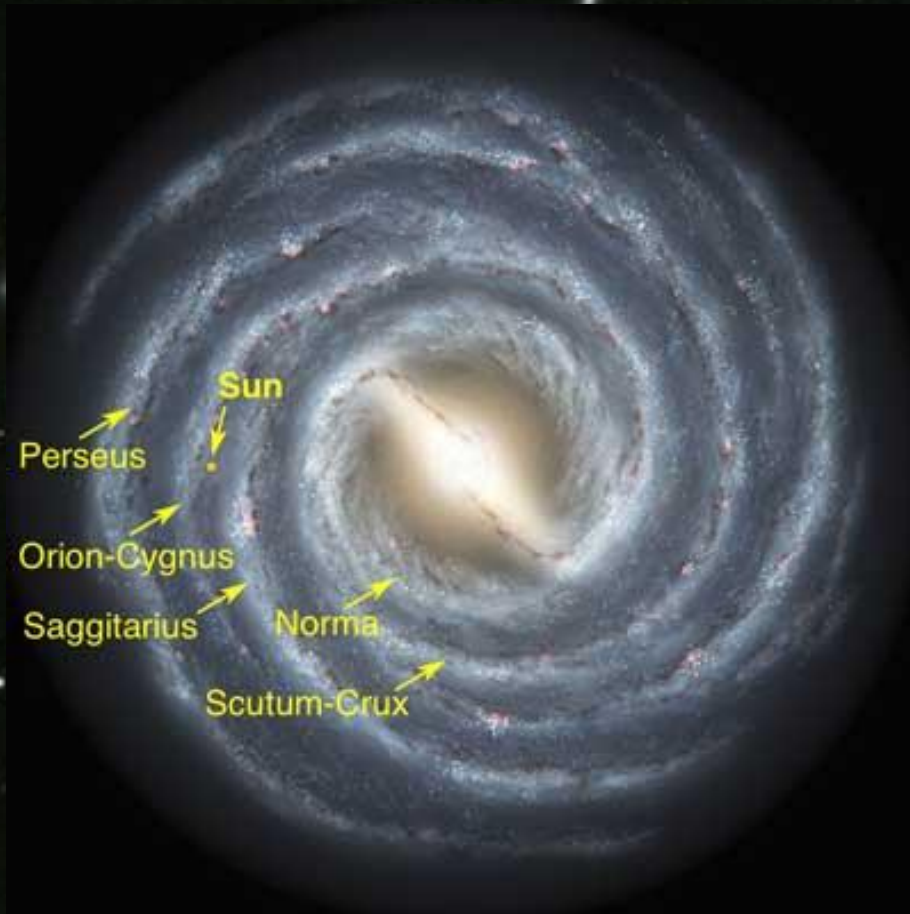
Ana Branca: o Sol de amanhã



Nossa Galaxia: a Vía Láctea

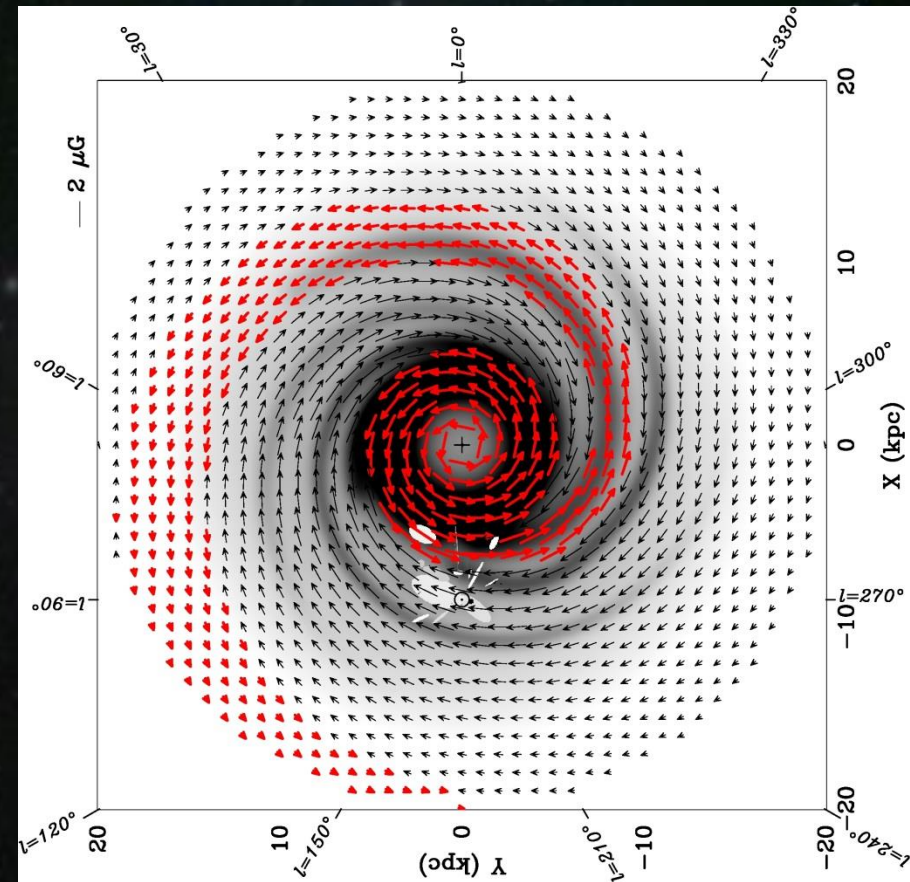
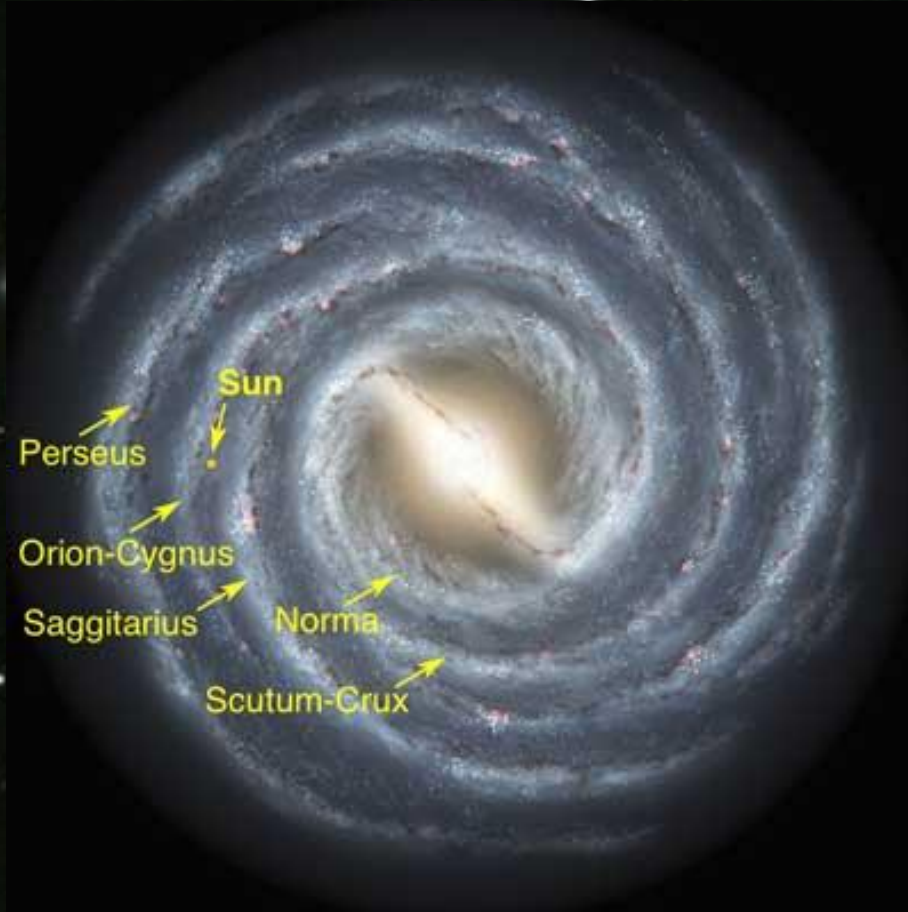


Campos magnéticos na Via Láctea



Campo magnético da galaxia:
1 Milhao de vezes menor que o da Terra!

Campos magnéticos na Via Láctea



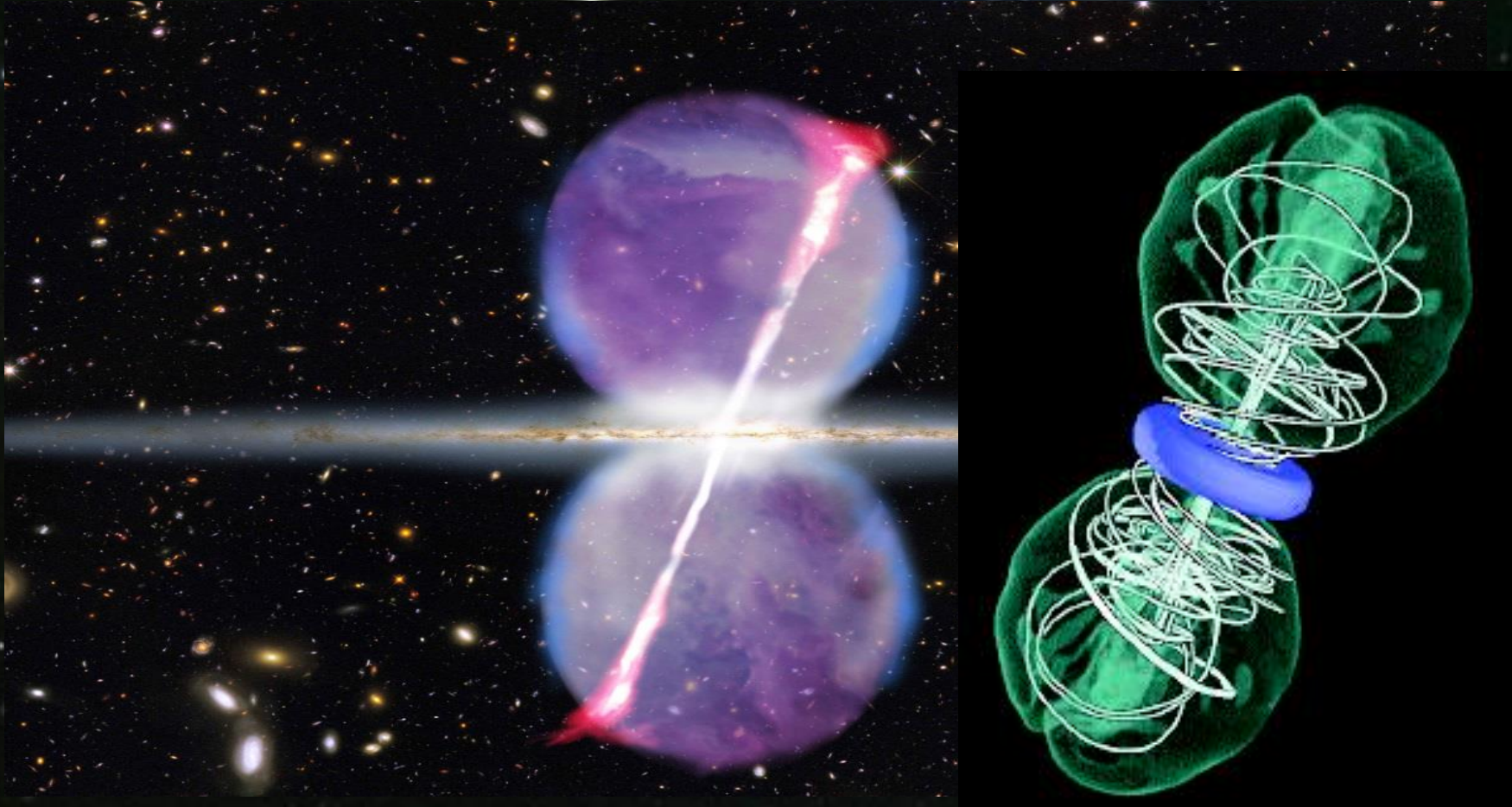
Campo magnético da galaxia:
1 Milhao de vezes menor que o da Terra!

Origen dos campos magnéticos da Vía Láctea



Sementes de campos magnéticos das explosões de supernovas:
amplificados pela rotação gerando campos espirais

Campos magnéticos no núcleo da Via Láctea



buraco negro no núcleo da nossa galaxia
Descoberta de um jato de raios gama: 27000 lyr

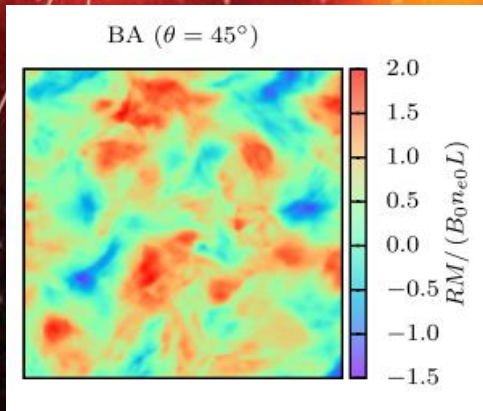
Campos magnéticos em outras galaxias



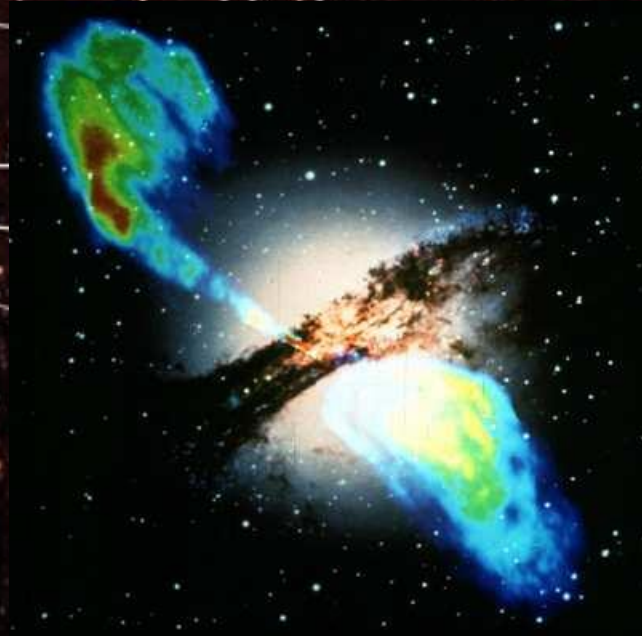
Magnetismo Intergaláctico

The background of the slide is a deep space image filled with numerous small, distant galaxies. Overlaid on this are several bright, glowing orange and yellow elliptical shapes, which represent the cores of galaxies or clusters. A network of thin, white, curved lines is drawn across the image, illustrating the paths of intergalactic magnetic field lines. These lines are more densely packed around the bright galactic cores and curve gracefully across the voids between them.

Origem do Magnetismo nos aglomerados de Galaxias ?

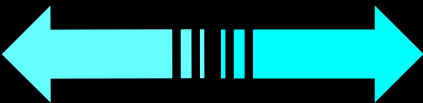


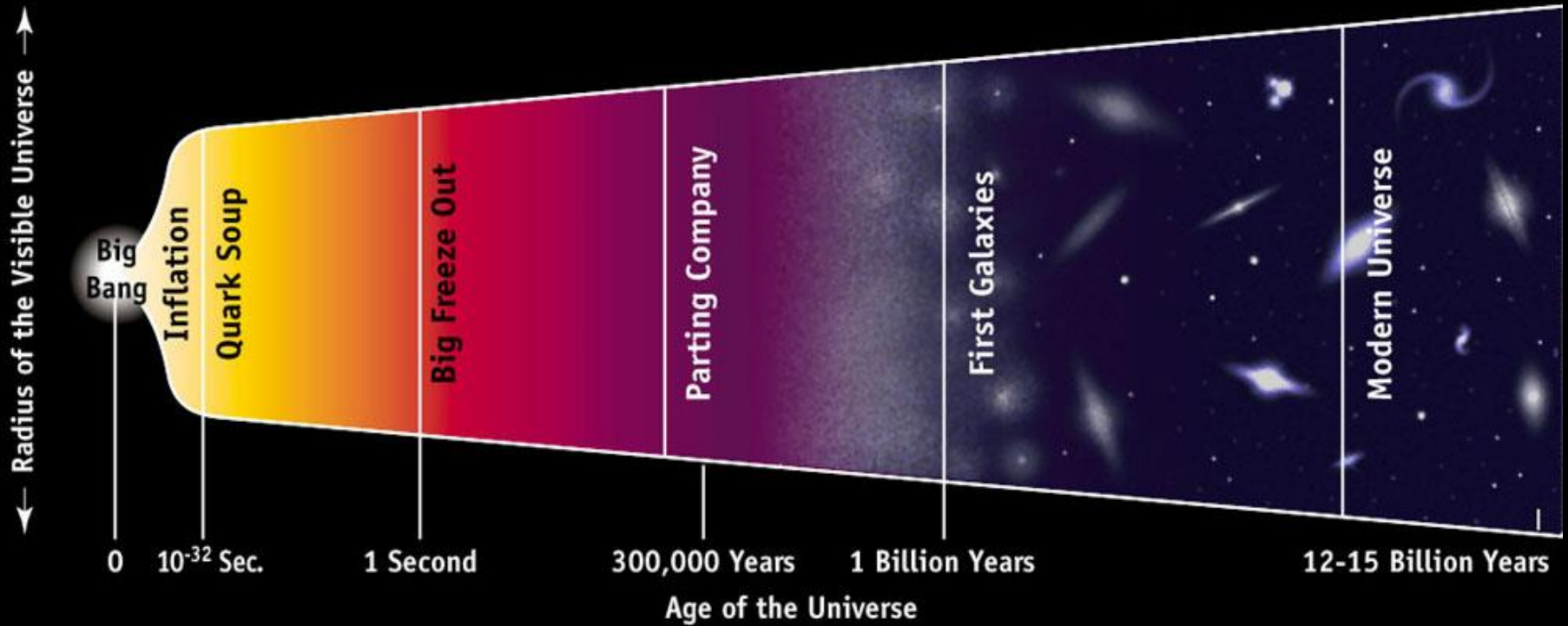
Amplificacao por turbulencia



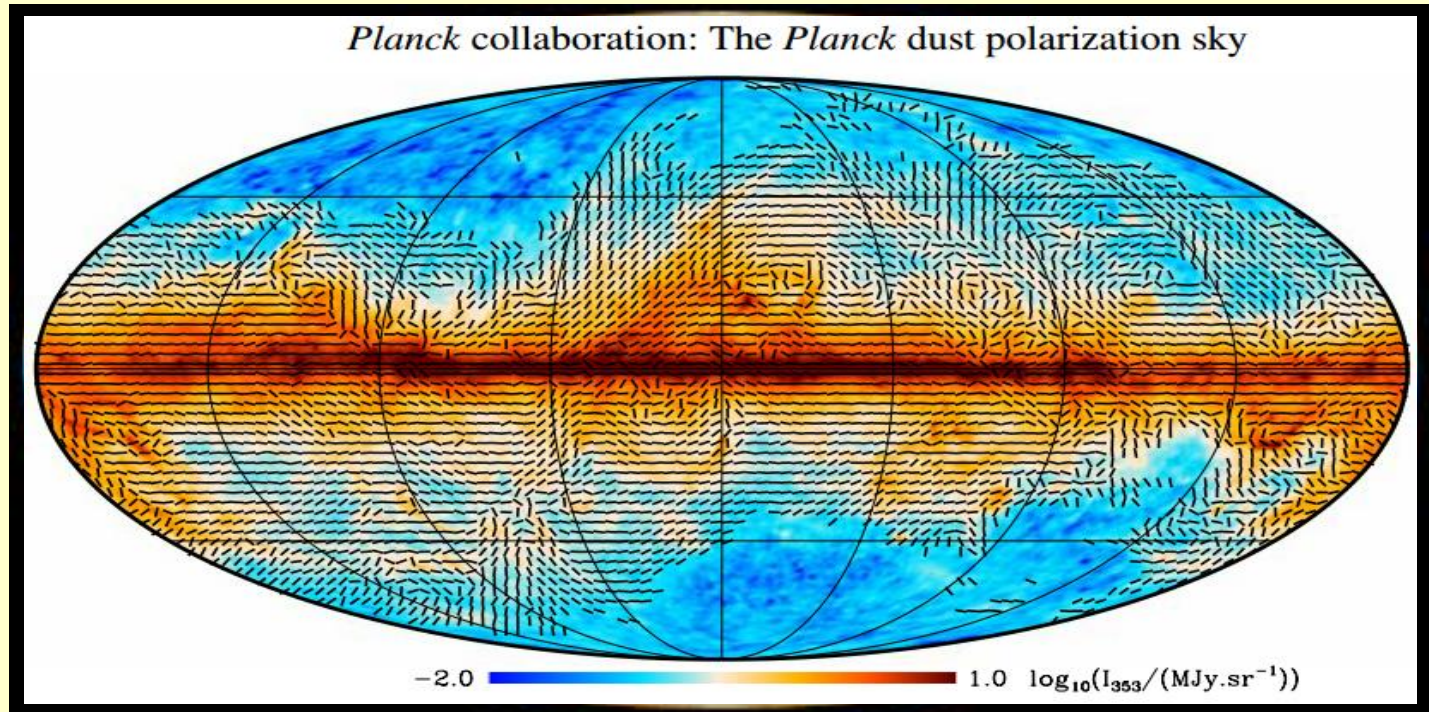
Ventos e jatos de Galaxias

Campos Magnéticos no Universo Primordial?

Física de Partículas  Astrofísica



O eco do Big Bang e o eco do Universo magnético?



**Fundo Cósmico da Radiação de Microondas
(satélite PLANCK)**

**Campos Magnéticos podem haver afetado
a flutuações da Radiação Cósmica?**

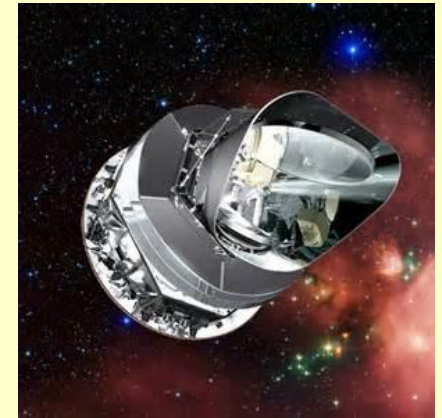
Instrumentos do Seculo 21



← ALMA LOFAR →



← LLAMA (Argentina-
Brazil) (2016)

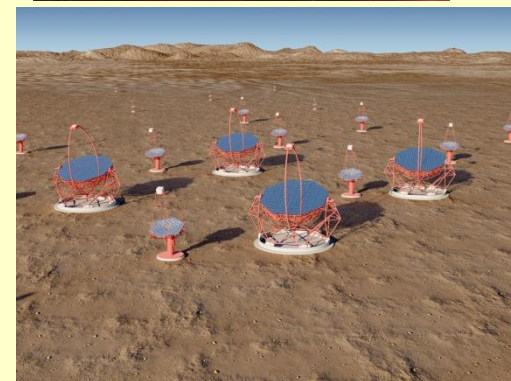


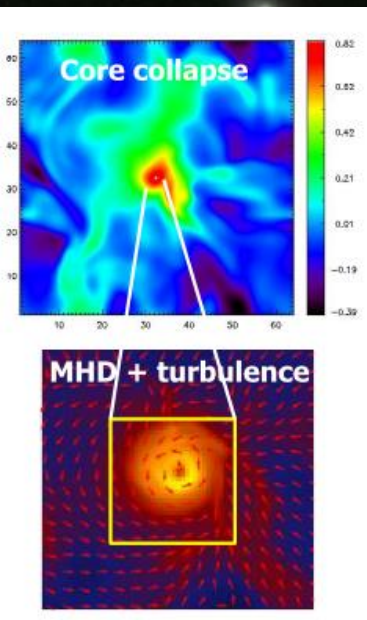
PLANCK →



← SKA (2026)

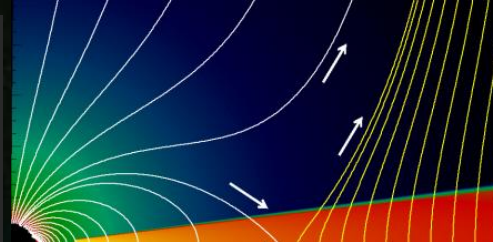
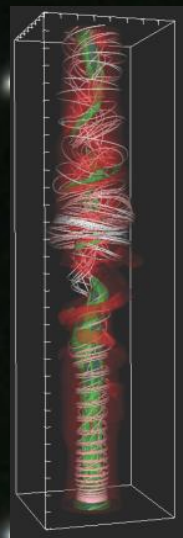
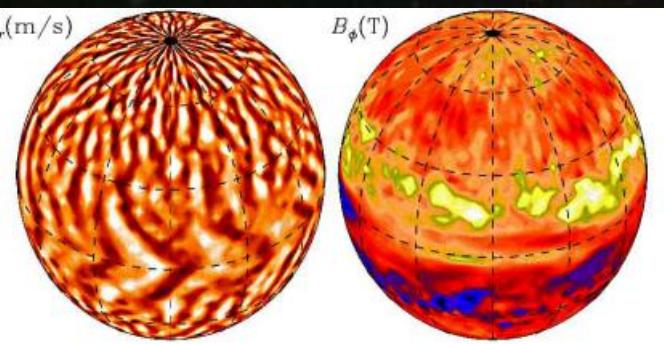
CTA (2024) →





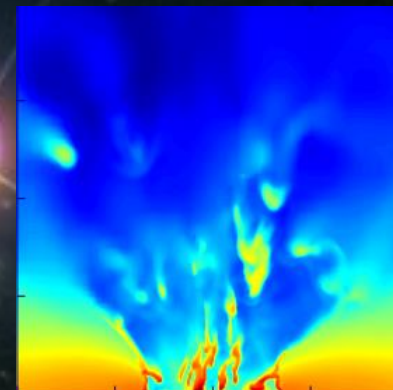
Star
Formation -
Magnetic
turbulence
connection

Solar Dynamo



Jets &
accretion
disks

Galactic
winds

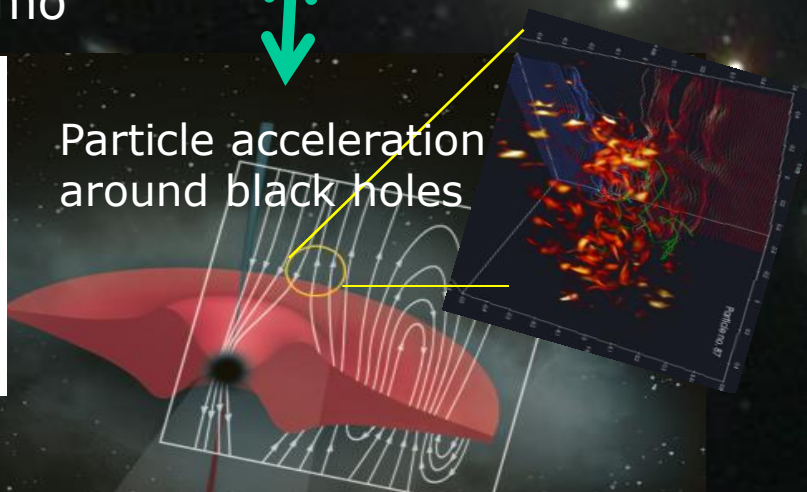


**GAPAE:
MHD
Simulations**

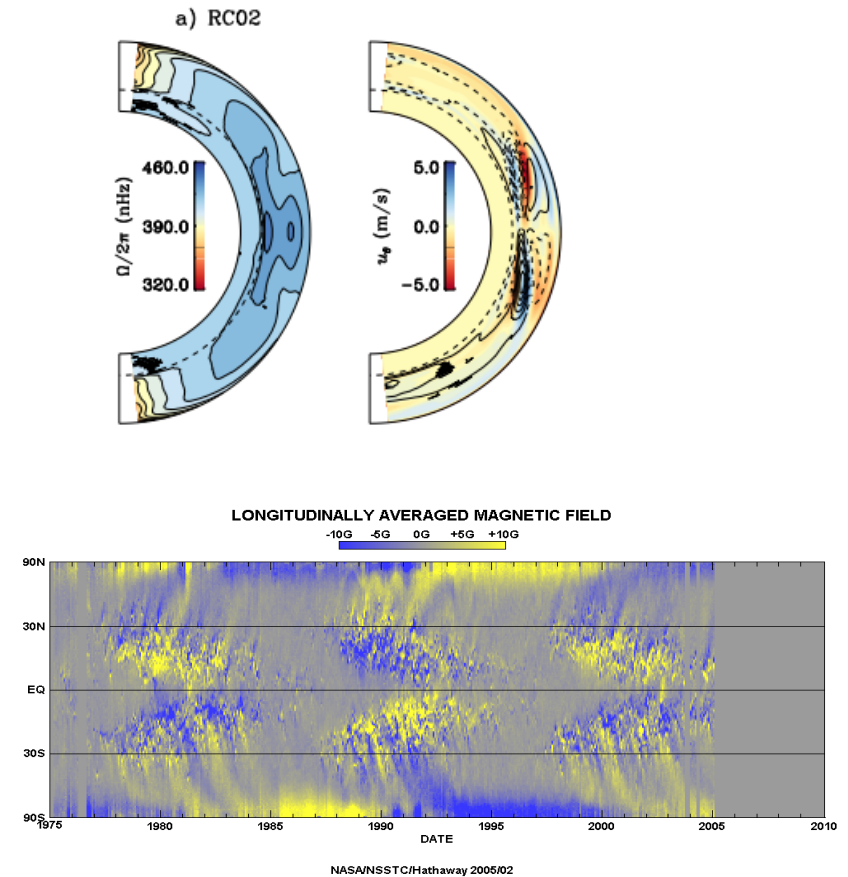
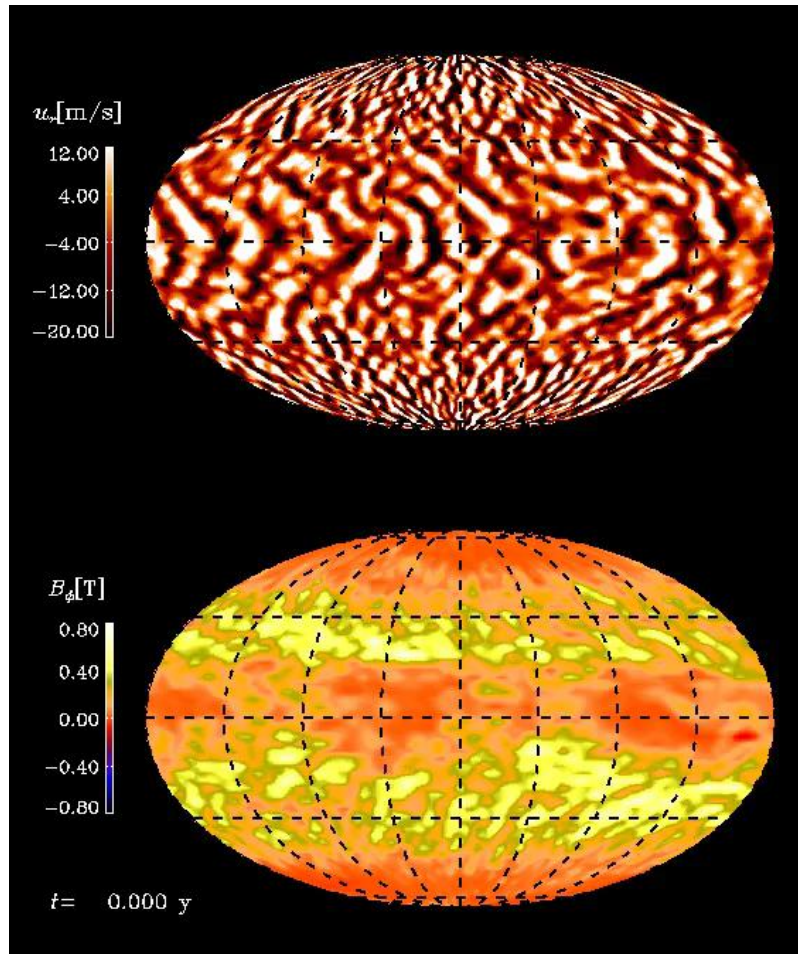
Clusters of
Galaxies



Particle acceleration
around black holes

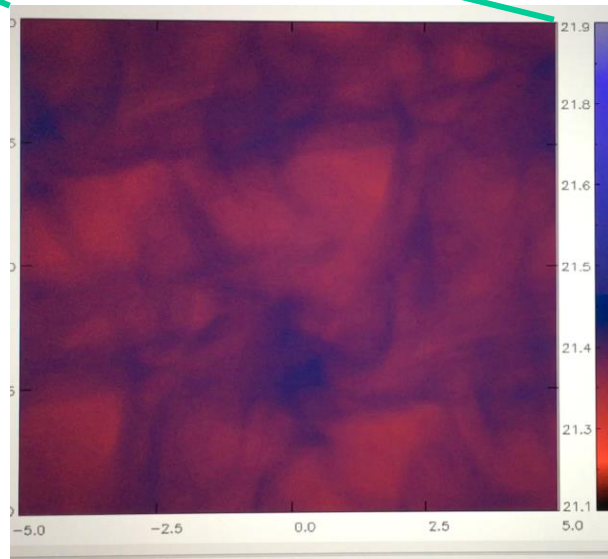
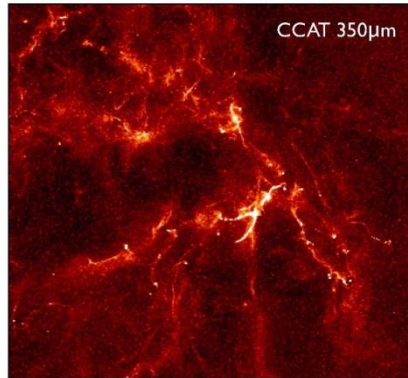
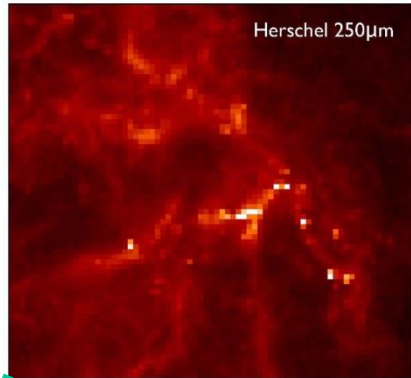


Solar Dynamo 3D MHD simulations



Guerrero, Smolarkiewicz, de Gouveia Dal Pino, Kosovichev, & Mansour, ApJ 2016a, ApJ Letters 2016b

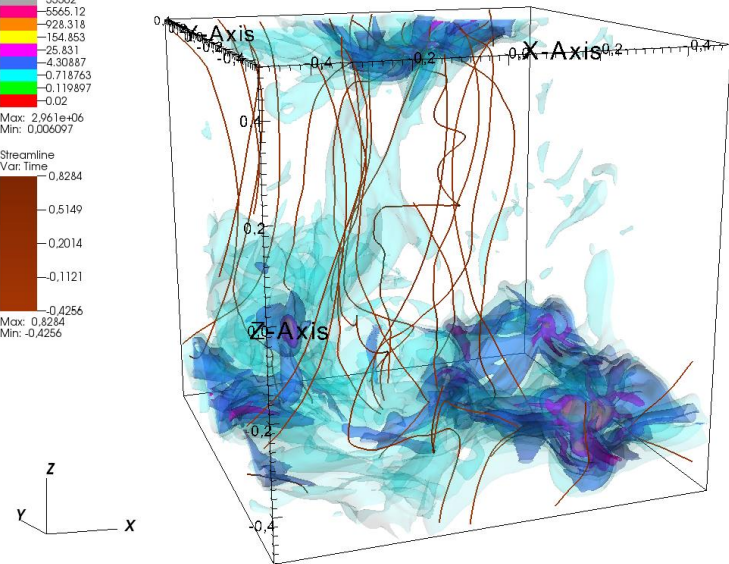
3D MHD Simulations of Star Formation



- MFs force the gas to accumulate along the field lines forming filaments as observed in the interstellar medium

DB: mov_mhd_0044.vtk
Cycle: 44 Time:44

Contour
Var: dens
-200000
-33362
-5565.12
-928.318
-154.853
-25.831
-4.30887
-0.718763
-0.119897
-0.02
Max: 2.961e+06
Min: 0.006097
Streamline
Var: Time
0.8284
0.5149
0.2014
-0.1121
-0.4256
Max: 0.8284
Min: -0.4256

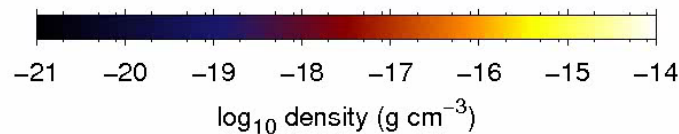


user: barreto
Wed Apr 5 15:46:59 2017
Wed Apr 5 15:35:36 2017

3D MHD simulations of Star Formation: Core collapse and proto-stellar disk formation

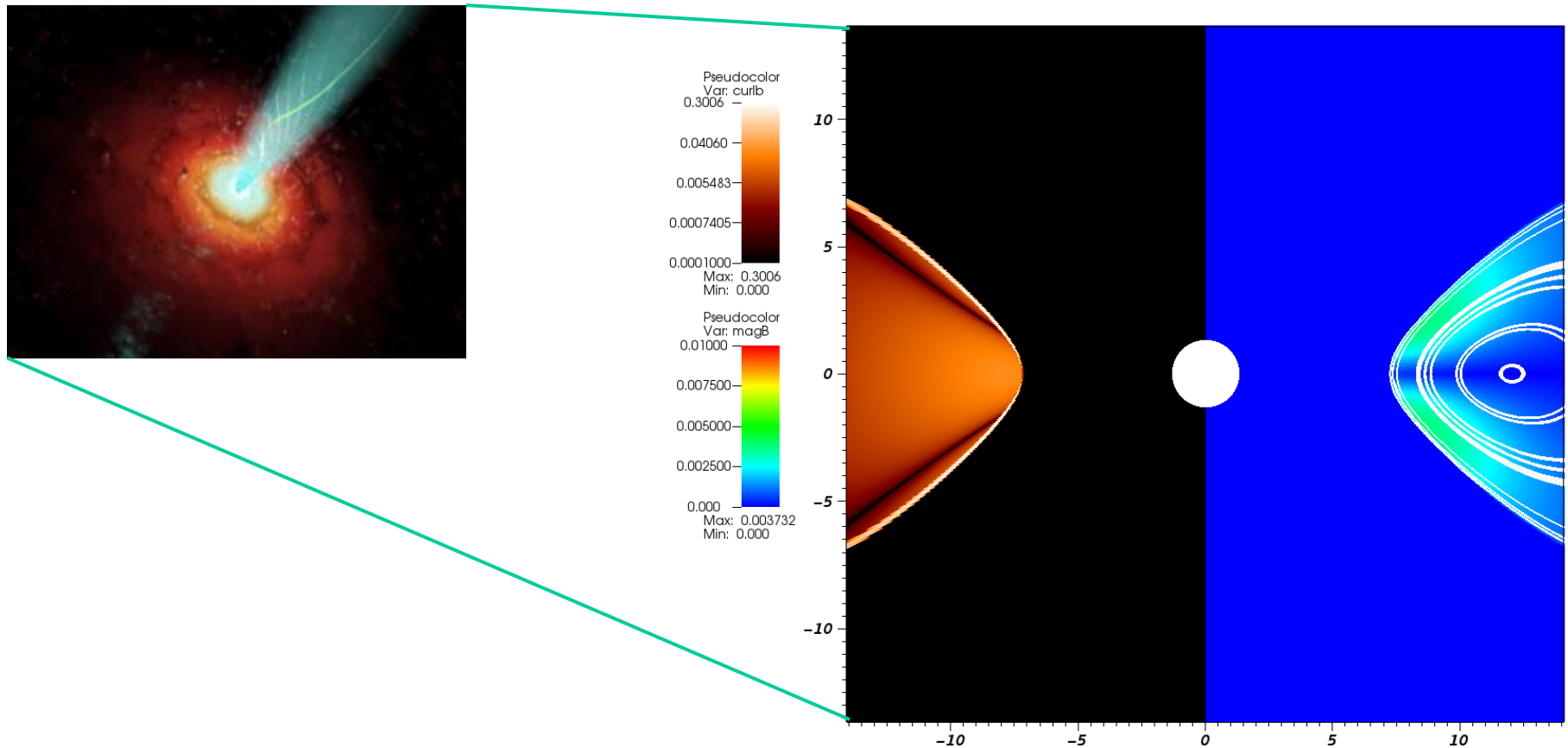
Magnetic fields (MFs) and turbulence influence star formation:
turbulence helps the removal of excess of MF that is dragged-in, and
allows the core and disk to form under the action of gravity

$t = 0.000$ Myr



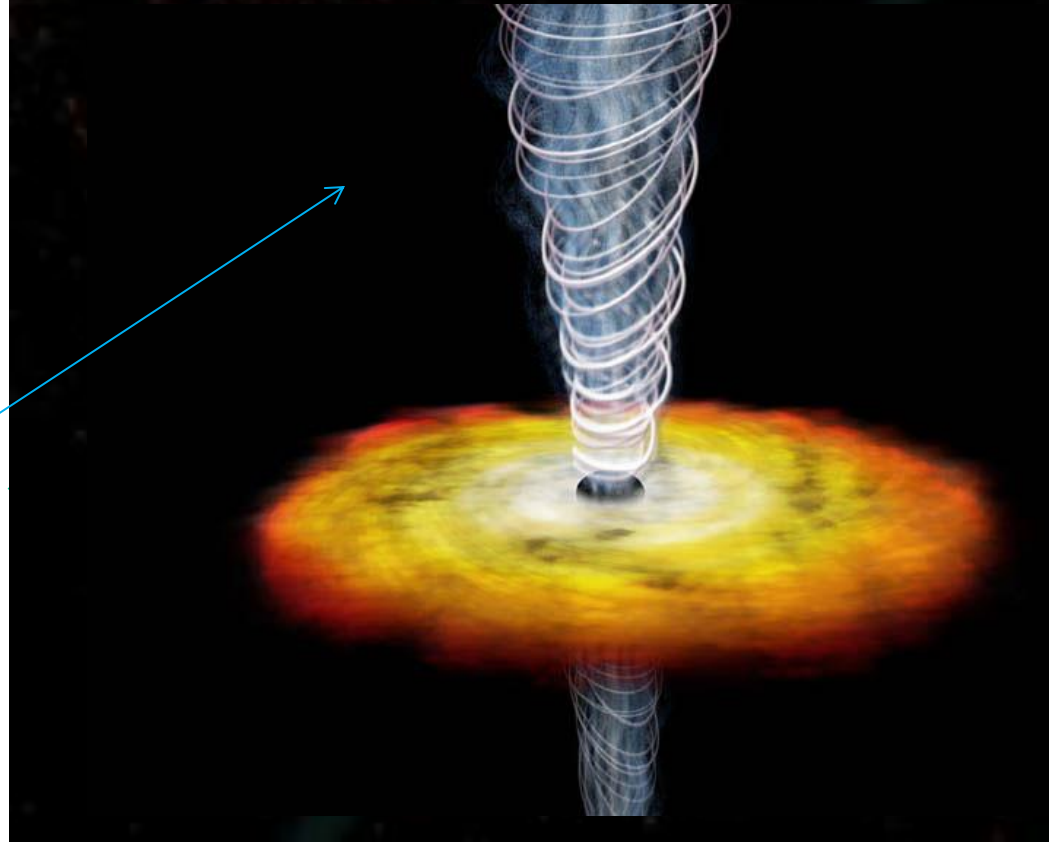
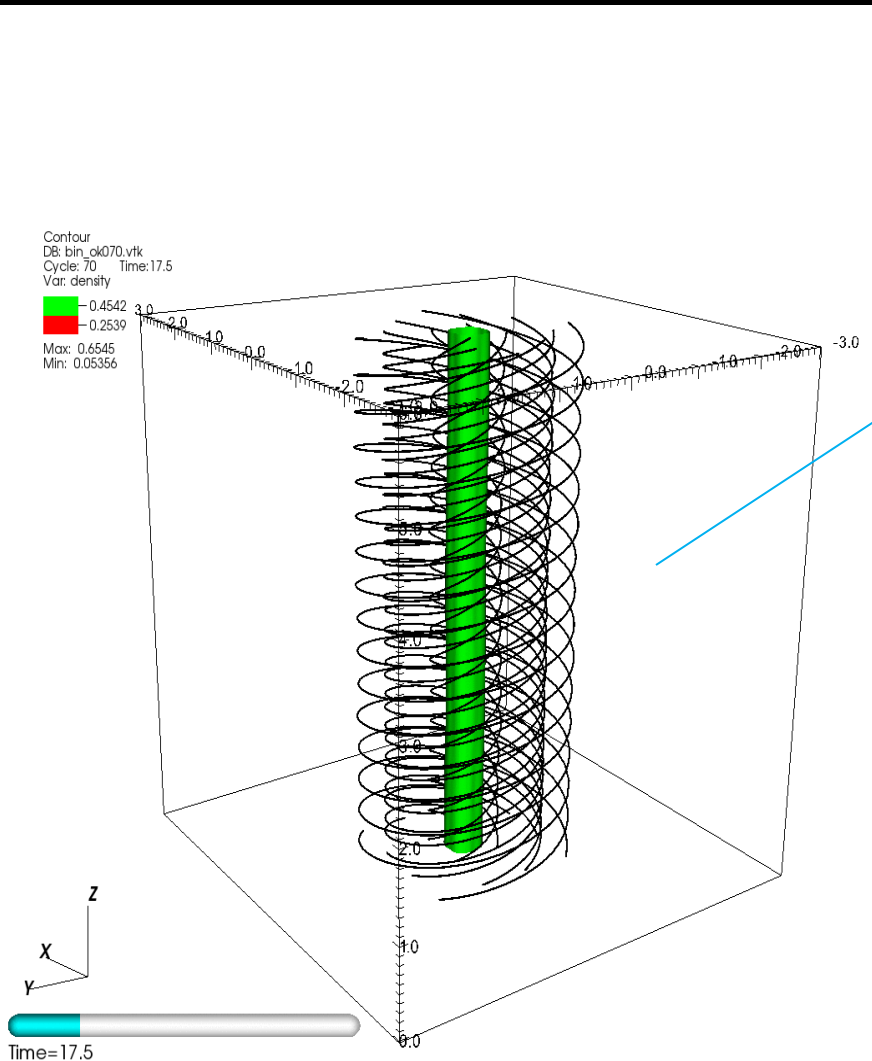
**Santos-Lima, de Gouveia Dal Pino, Lazarian, ApJ 2012
MNRAS 2013**

MHD simulations of Accretion Disks around black holes



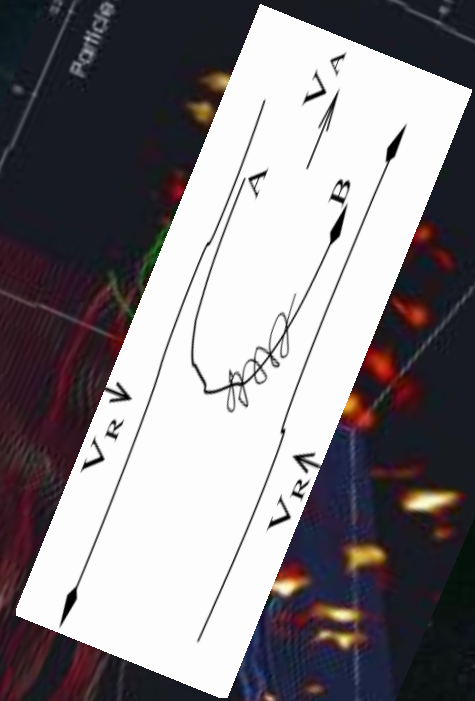
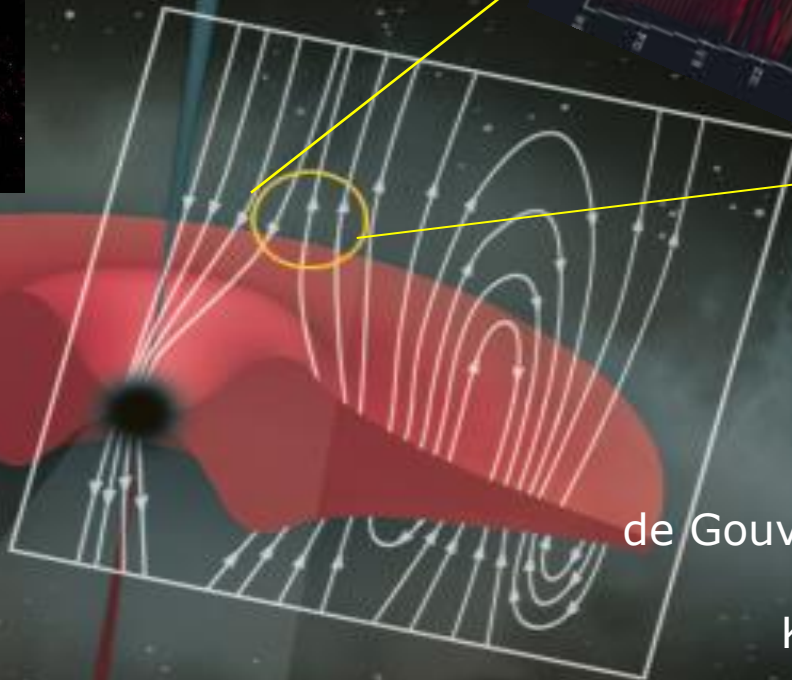
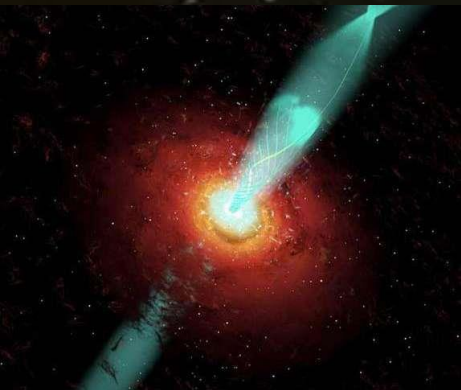
Kadowaki, de Gouveia Dal Pino, Stone 2018

3D Relativistic-MHD Simulations of Jets



Singh, Mizuno, de Gouveia Dal Pino, ApJ 2016

Aceleracao de raios cosmicos em campos magneticos nas vizinhanças de buracos negros

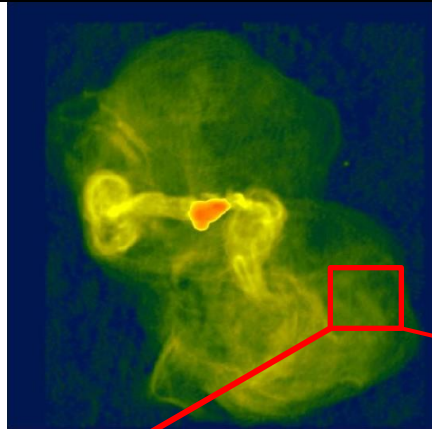


de Gouveia Dal Pino & Lazarian, A&A
2005

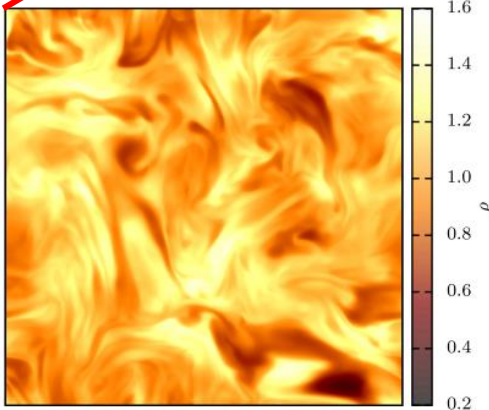
Kowal, de Gouveia Dal Pino &
Lazarian PRL 2012

3D MHD Simulations of the Intergalactic Medium: magnetic fields amplified by turbulence

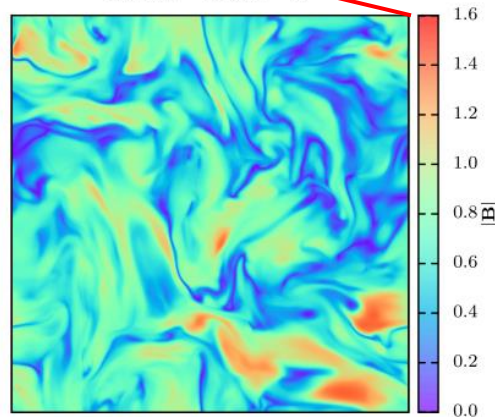
- MagneticFields influence galaxies and intergalactic gas evolution and dynamics



A1: $\beta_0 = 200$, $\nu_S = \infty$



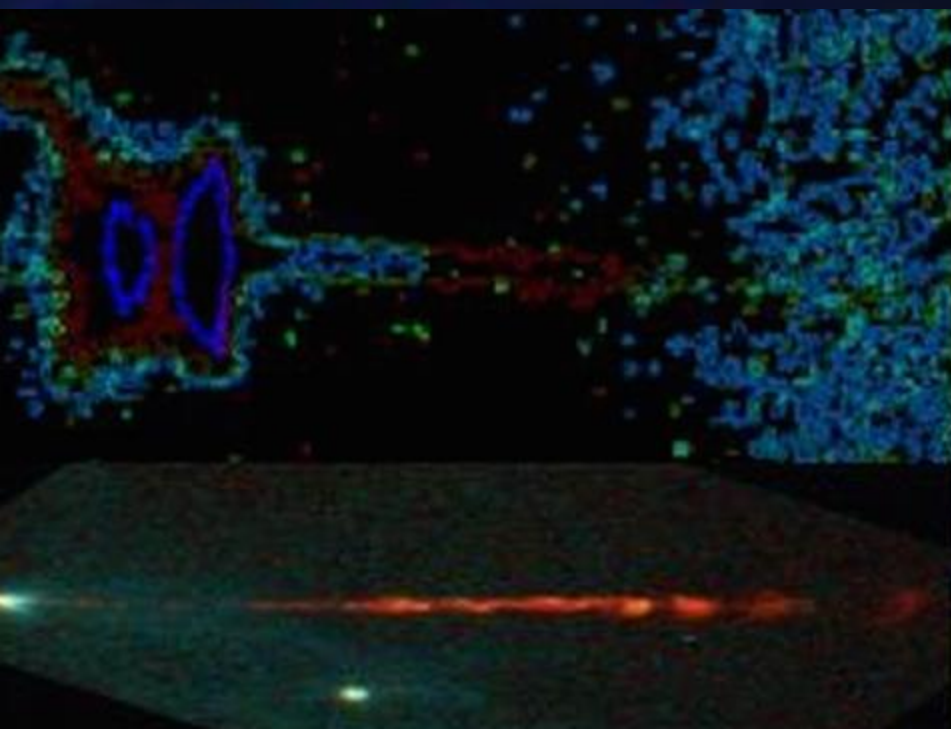
A1: $\beta_0 = 200$, $\nu_S = \infty$



Santos-Lima, de Gouveia Dal Pino et al., 2014, 2016



OBRIGADA



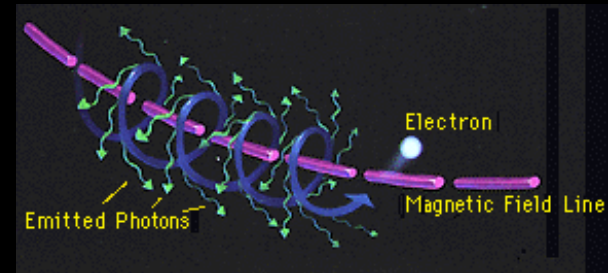
Measuring Magnetic fields

- Zeeman effect (within galaxy):

$$\Delta\nu = e B_{\parallel} / 2\pi m_e$$

- Polarized synchrotron emission (Beck and Krause 2005):

$$I \propto \int n_{CR} B_{\perp}^{1+\alpha} dl$$



- Faraday rotation of the diffuse polarized emission:

$$RM \propto \int n_e B_{\parallel} dl$$

