Draping of Cluster Magnetic Fields over Cores and Bubbles

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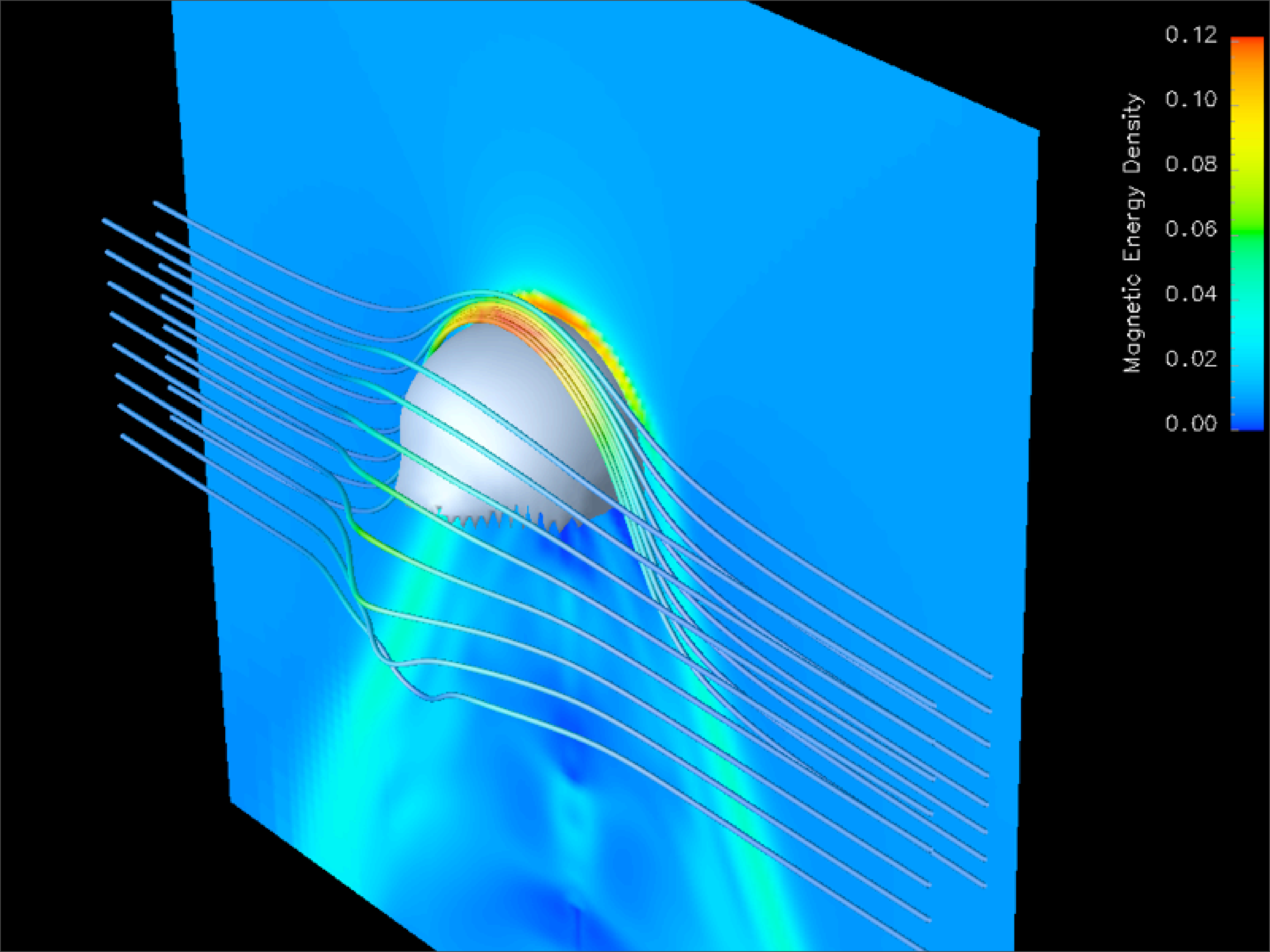
Christoph Pfrommer, CITA

CITA|ICAT

Or, ``an interesting side project with nothing at all to do with supernovae that I am working on before coming back, repentant, to supernova-related hydrodynamics”

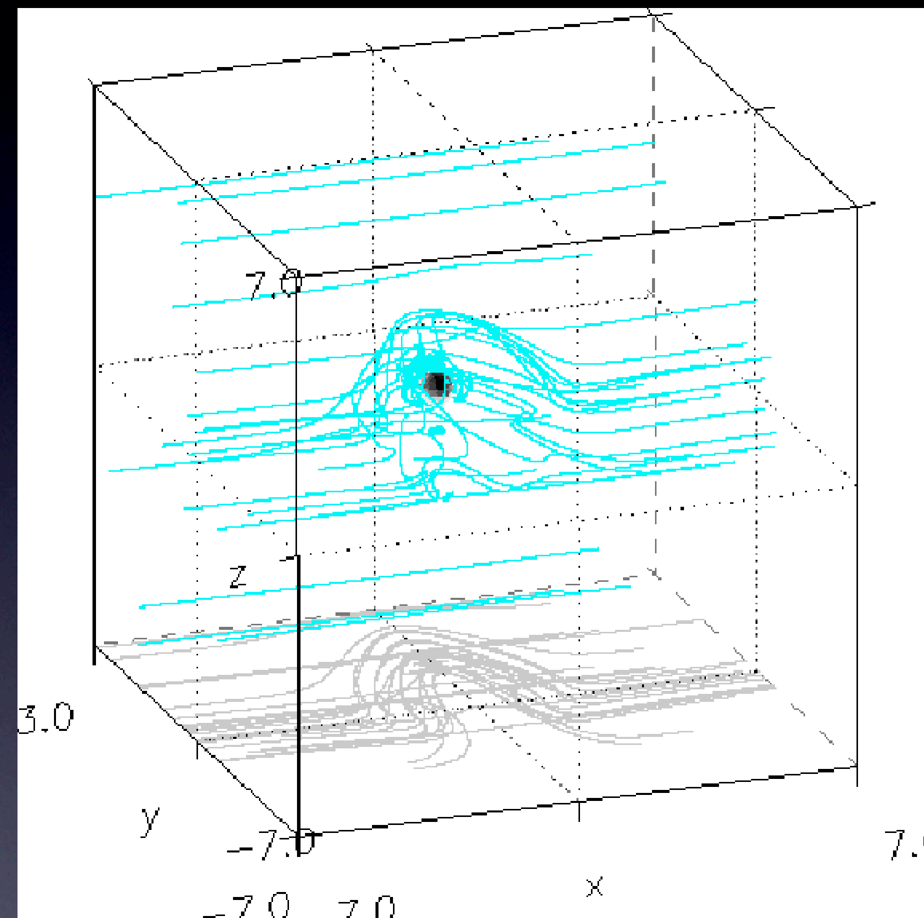


Magnetic Energy Density
0.12
0.10
0.08
0.06
0.04
0.02
0.00

Draping of Solar wind field around Earth

Birk1

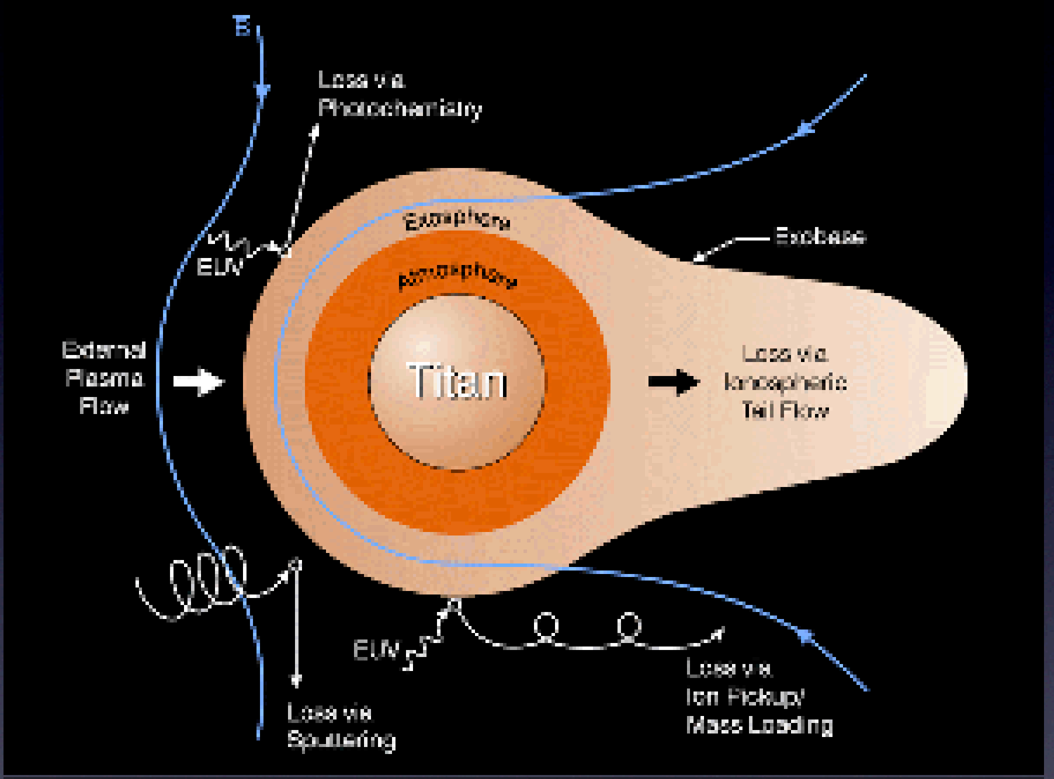
- Happens very quickly (figure to right -- 600 s)
- Can induce magnetic field in even a neutral atmosphere
- Earth Magnetic Field reversals may not be catastrophic to life



Birk et al (2004)

Draping of Saturn's Field over Titan

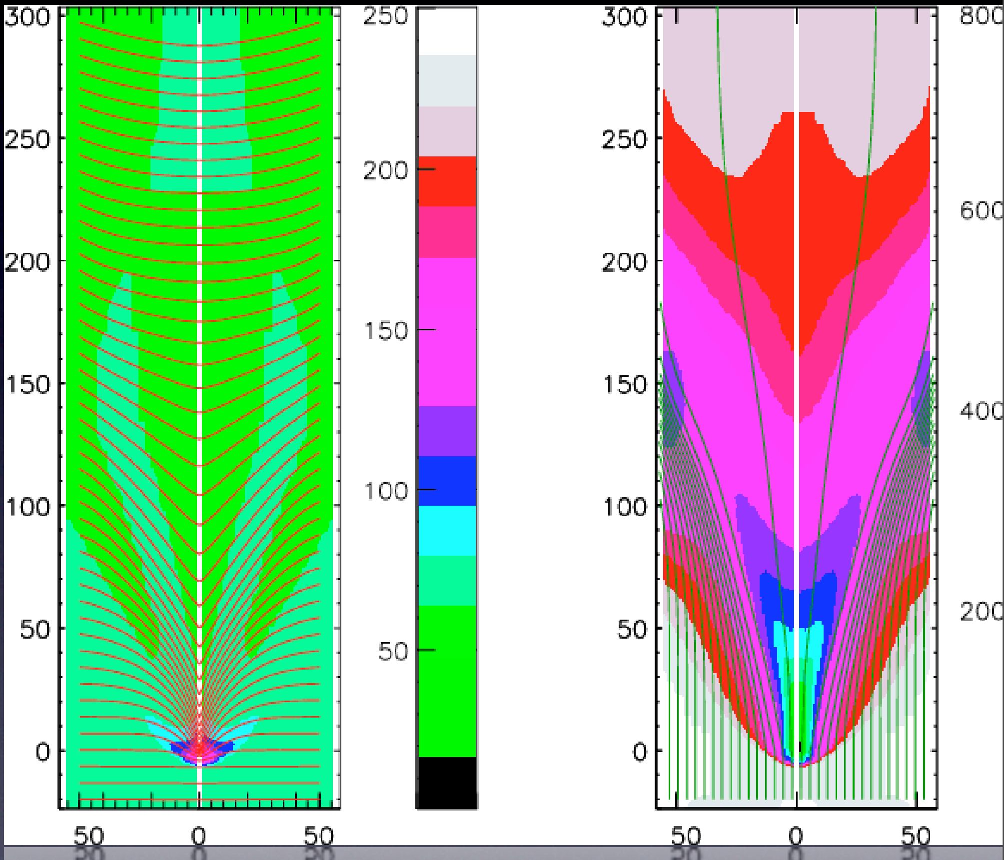
- Observable with Cassini
- Emission from draped field



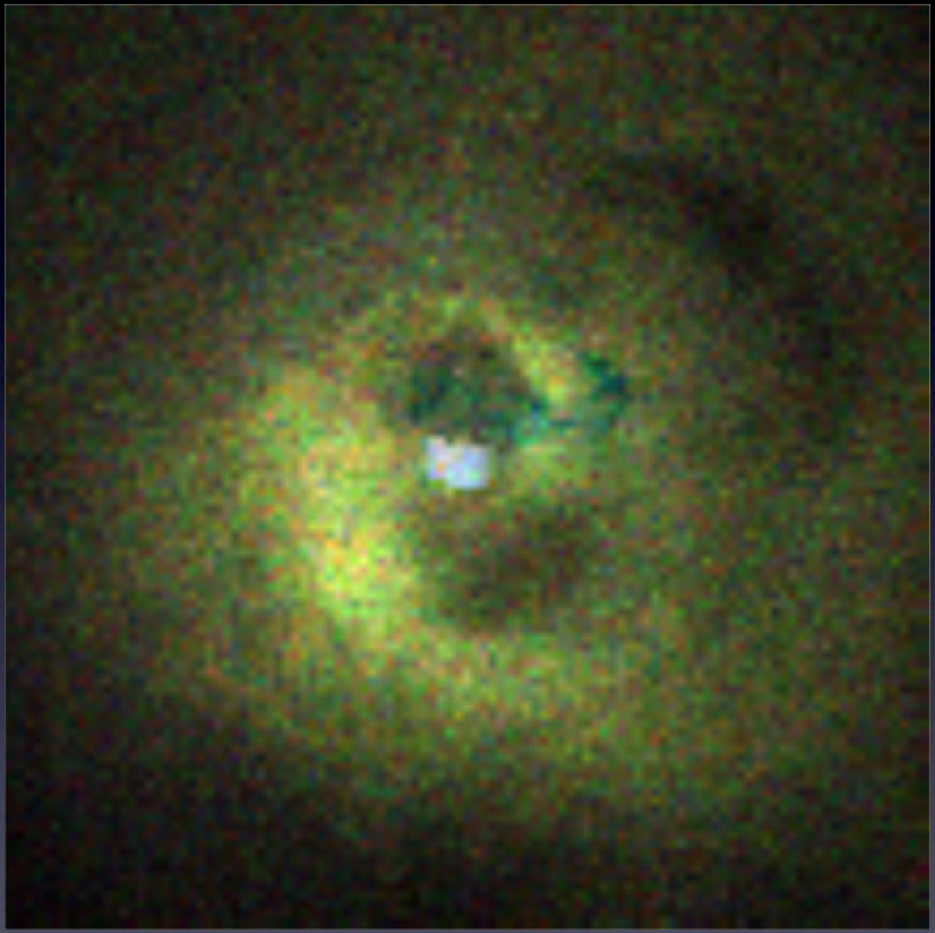
S.A. Ledvina, UC Berkeley

Comets in Solar Wind

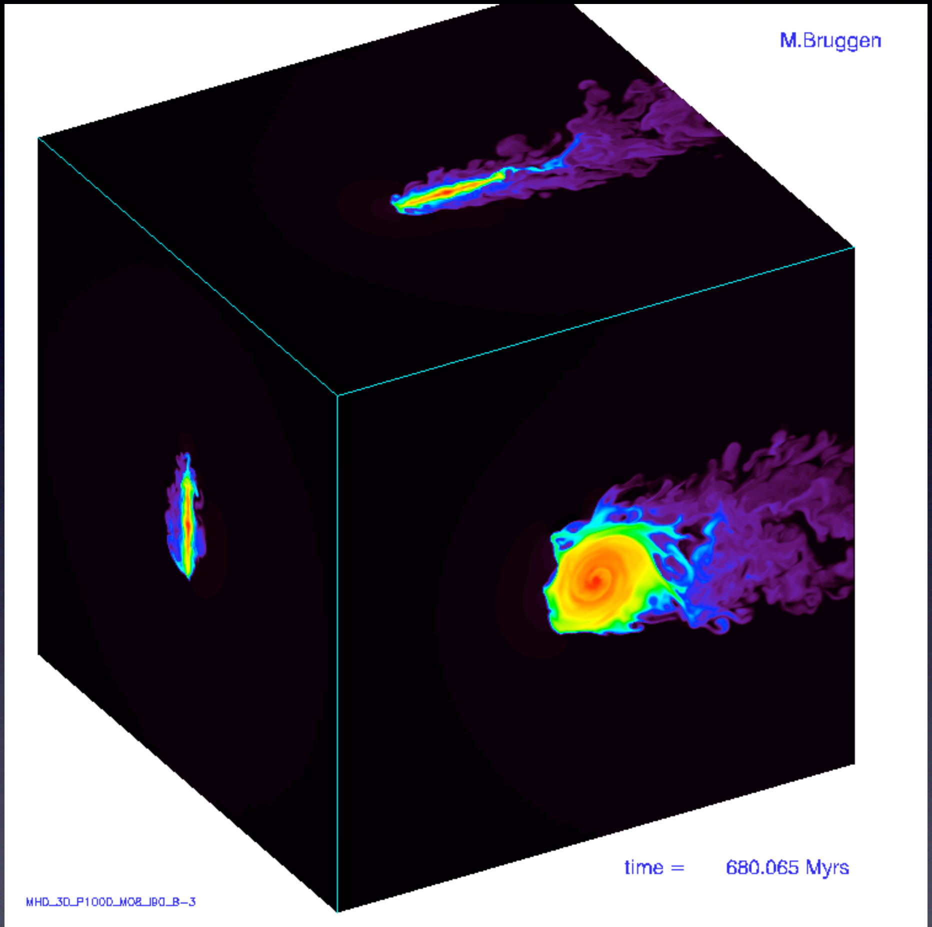
- Draping occurs and can distort velocity, magnetic fields in wind over significant distances



Wegman (2002)



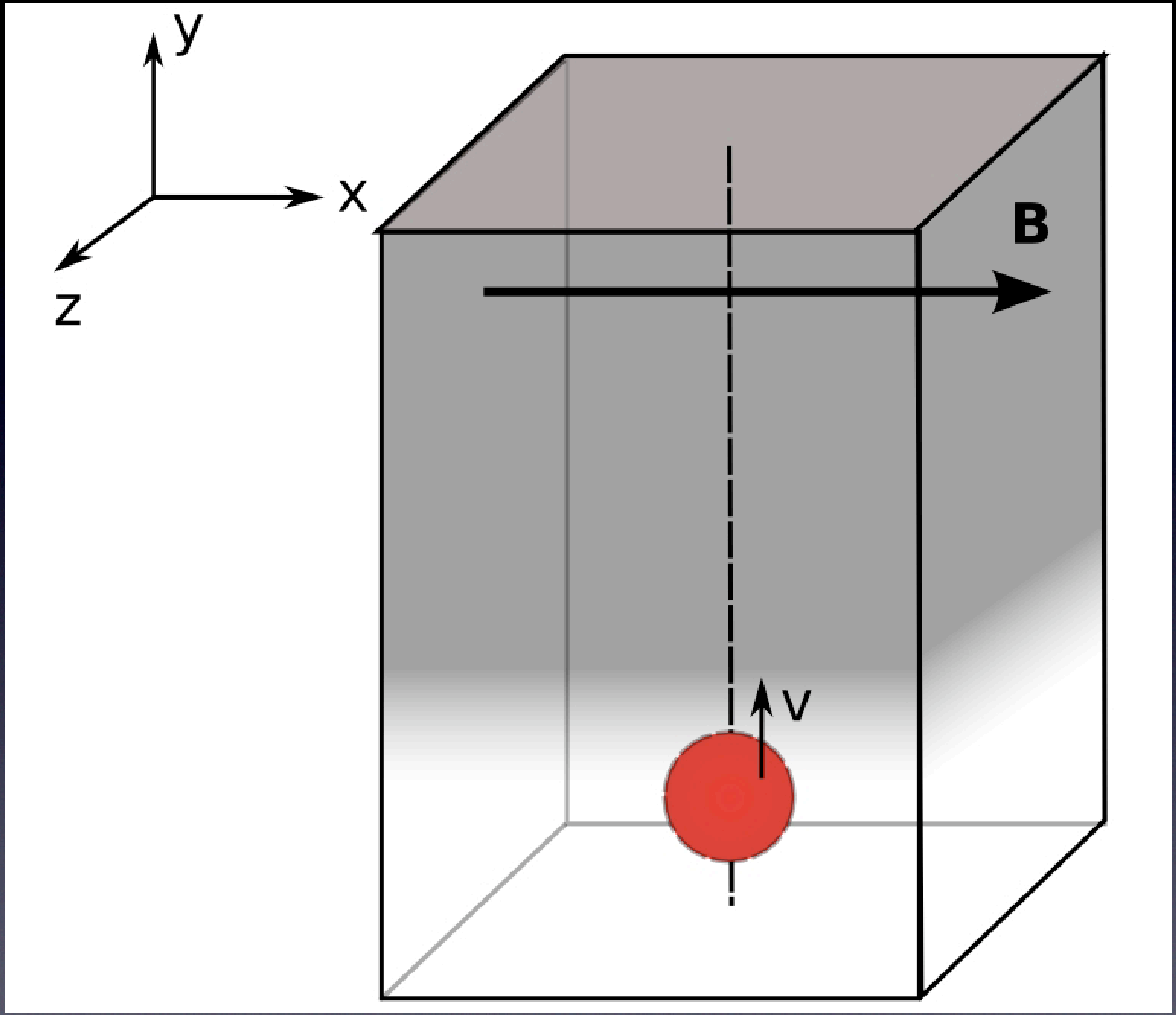
NASA/IoA/A.Fabian et al.



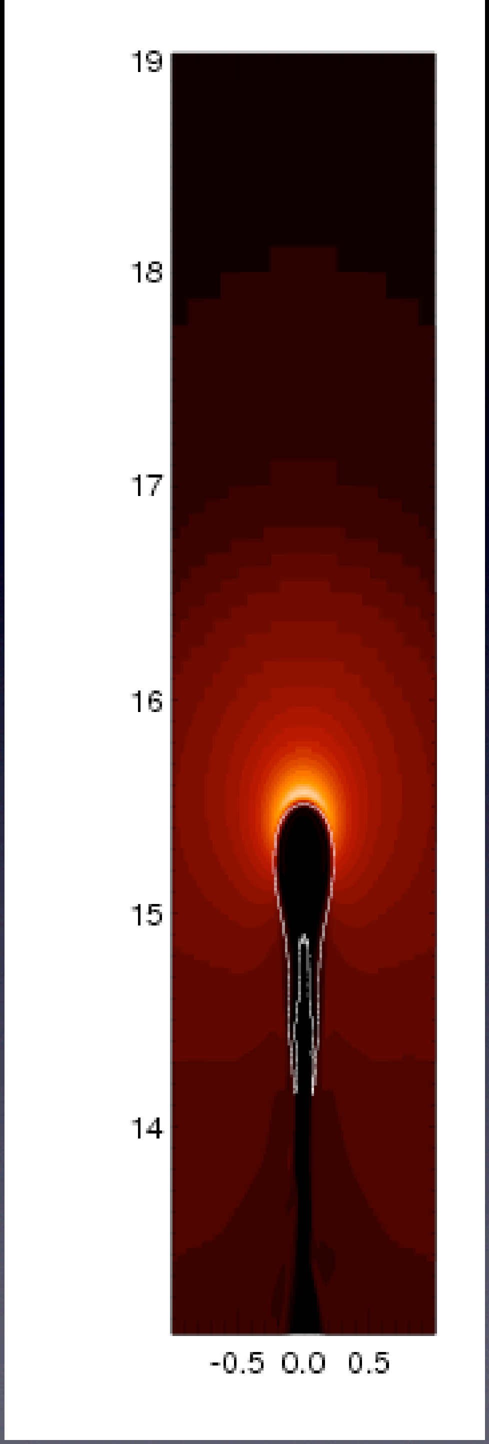
M. Bruggen, Bremen

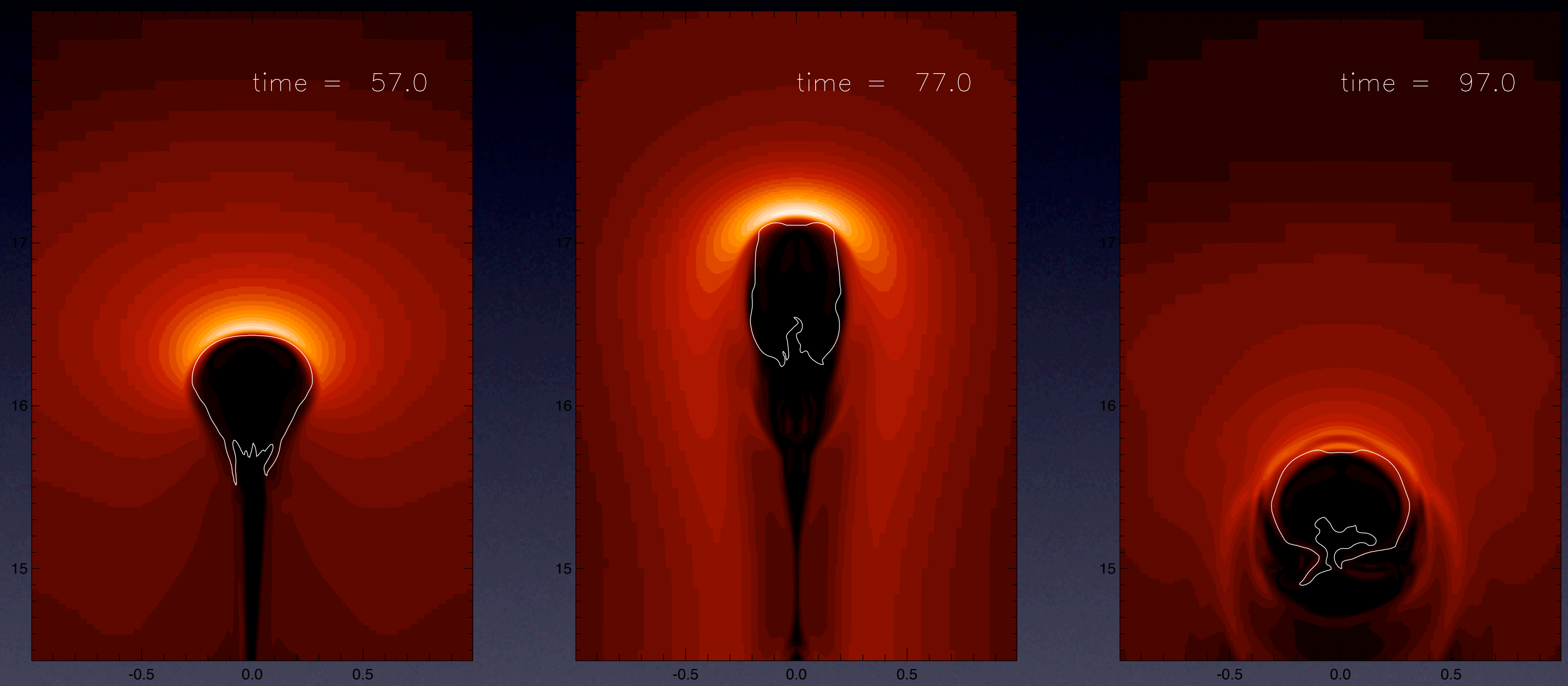
Our Contributions

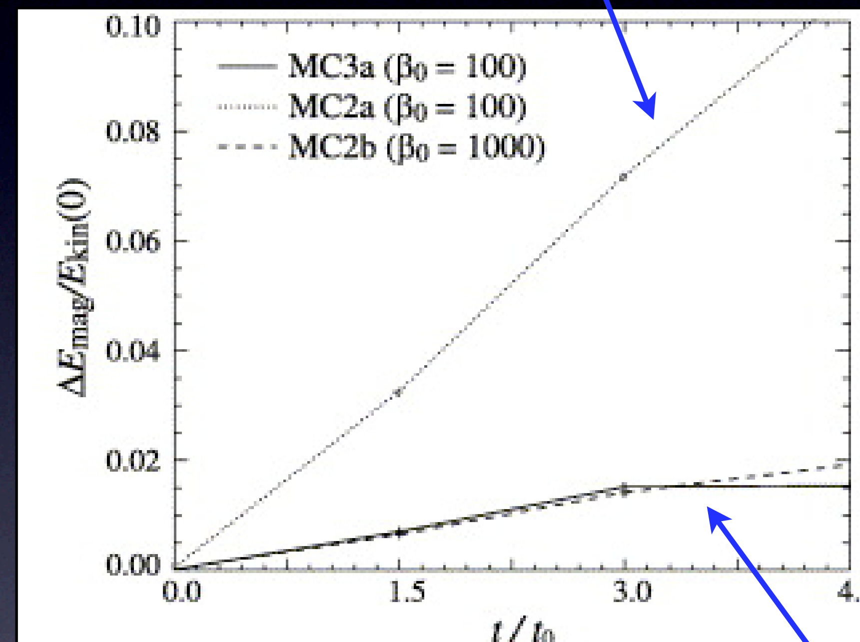
- 3D, AMR simulations of draping of magnetic fields in context relevant to galaxy clusters
- More careful analytic calculation in potential flow approximation to understand dynamics
- Linear theory analysis - can the thin layer do anything interesting?


y
x
z
B
v

Sometimes,
2D just
isn't enough...




time = 57.0
time = 77.0
time = 97.0
17
16
15
-0.5
0.0
0.5

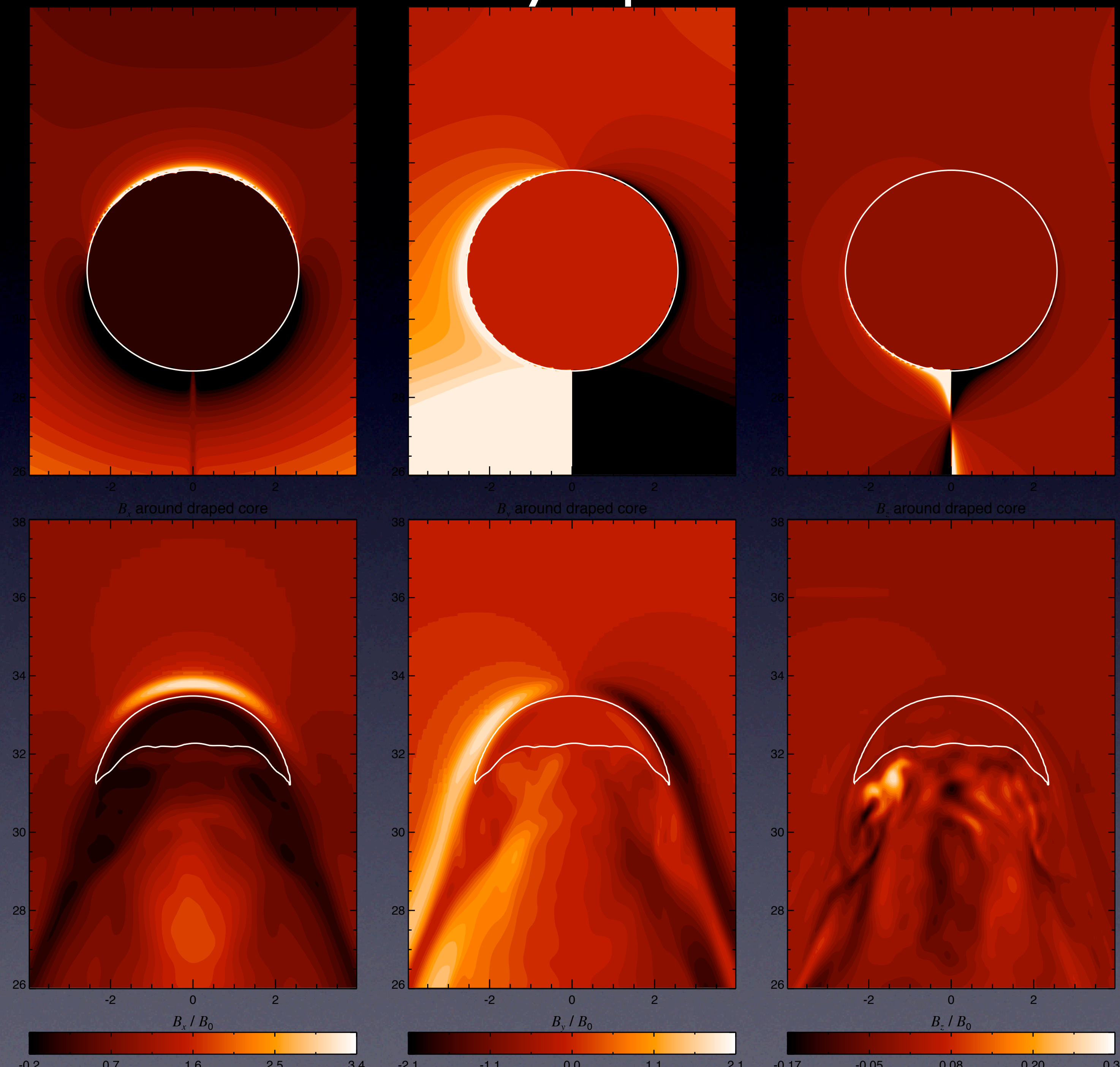


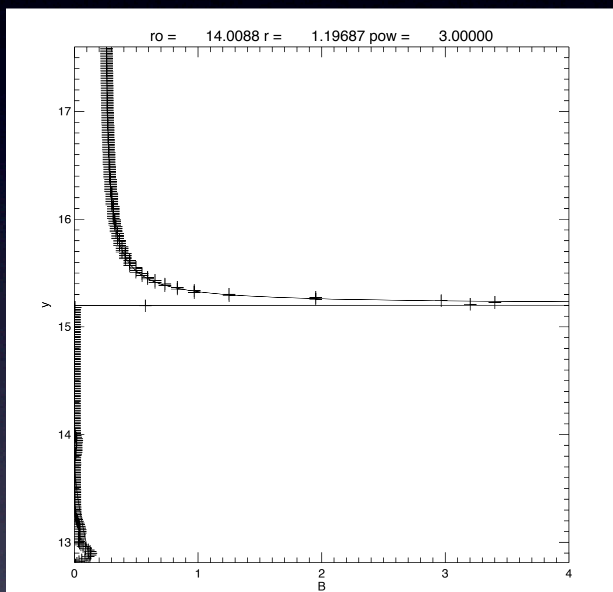
Asai et al (2005)

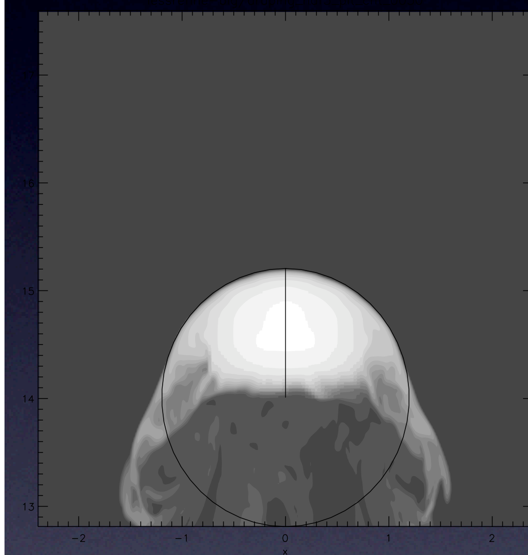
B^2 in x, y, z planes

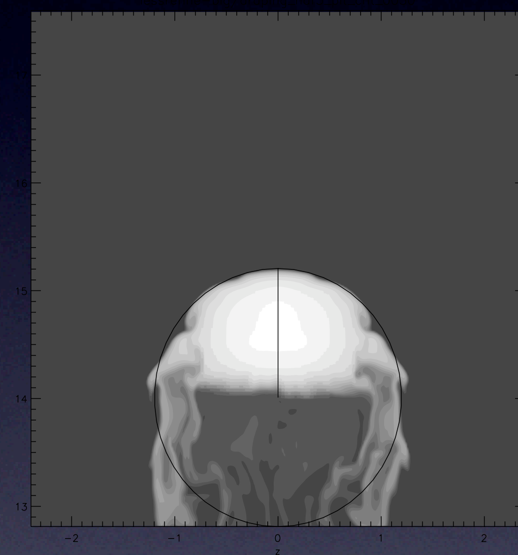
Potential flow around solid sphere

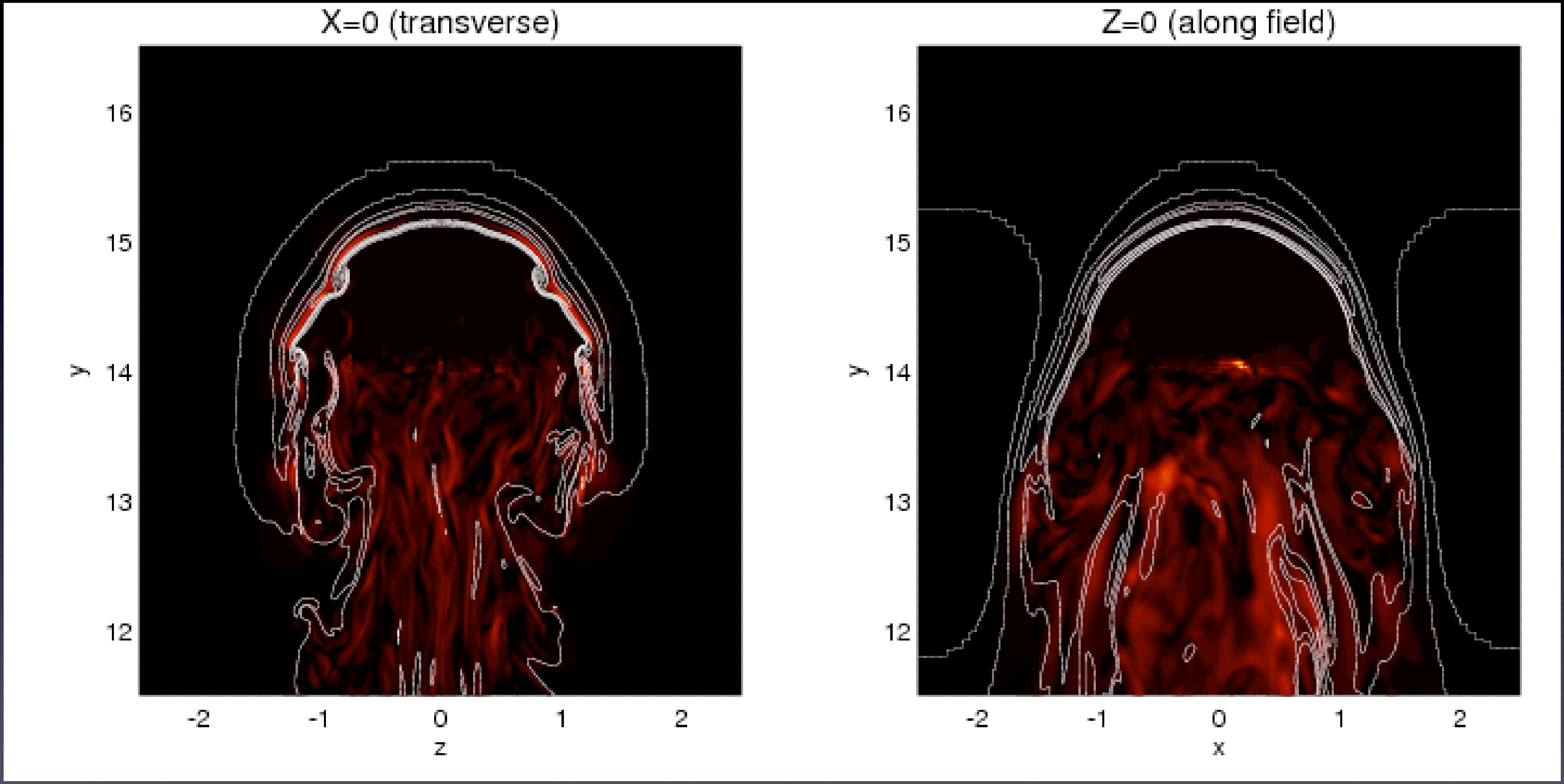
3d AMR results



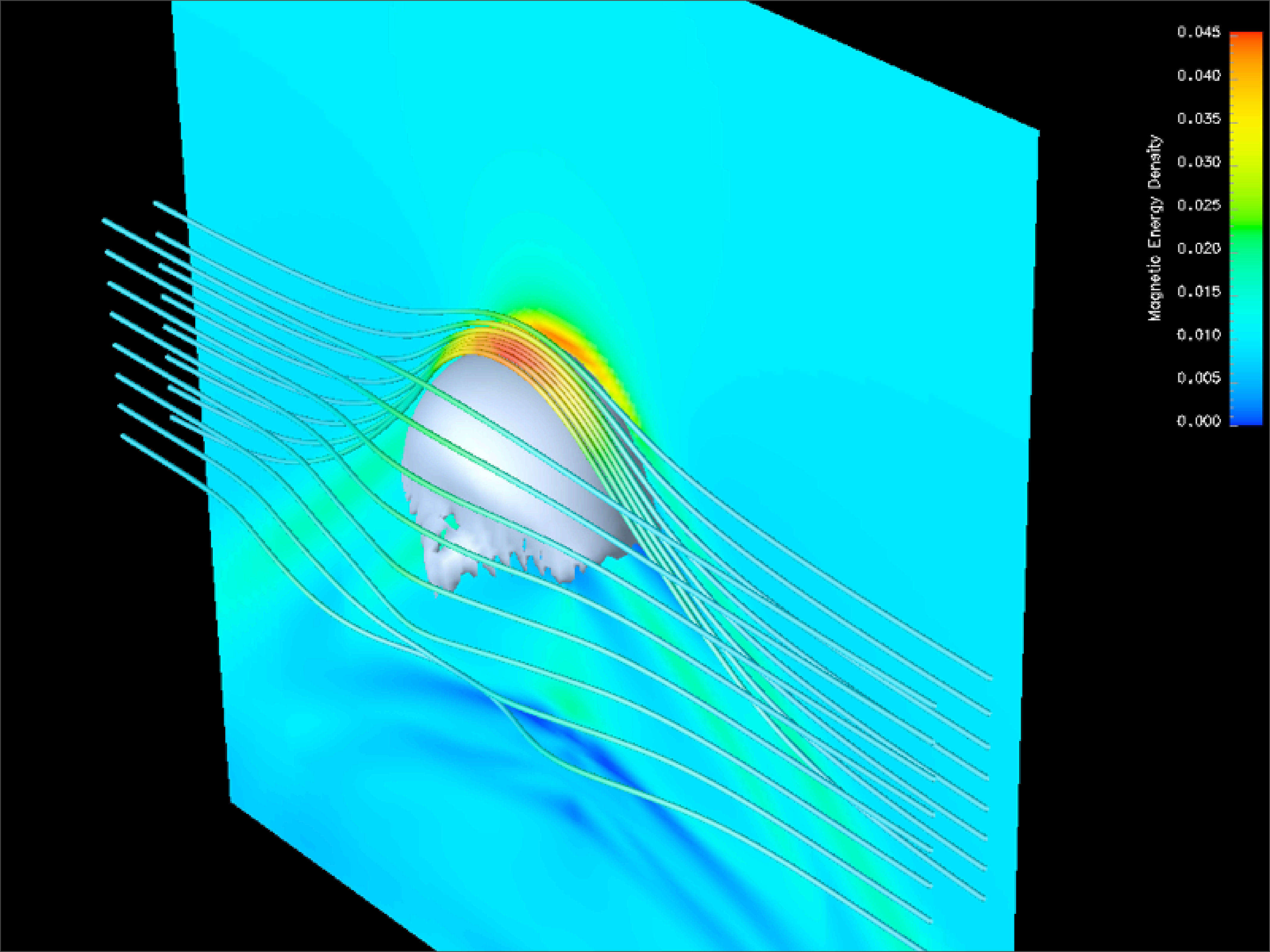

ro = 14.0088 r = 1.19687 pow = 3.00000
17
16
15
14
13
y
0
1
2
3
4
B

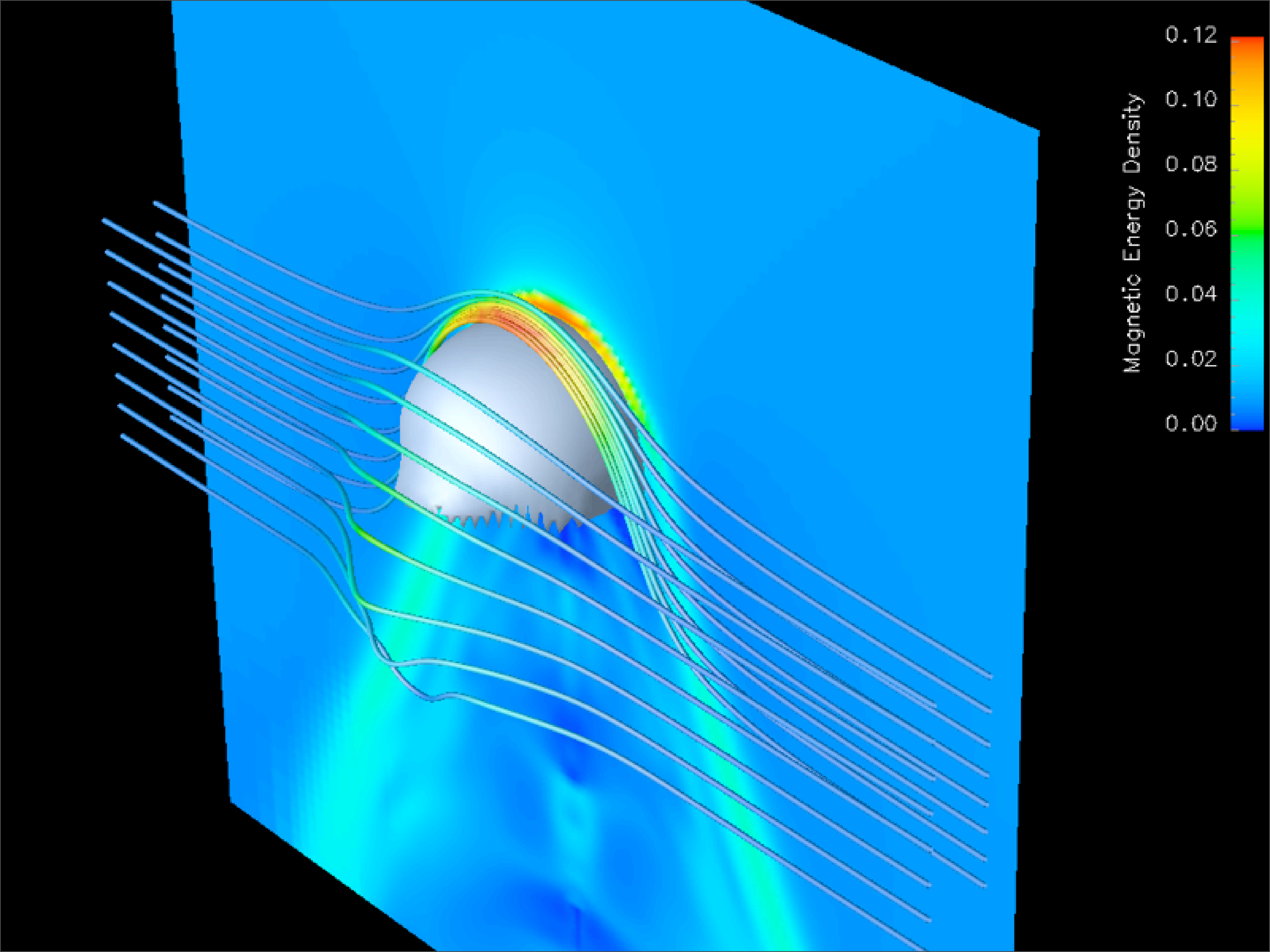

15
14
13
−2
−1
0
1
2
x


15
14
13
−2
−1
0
1
2
z



X=0 (transverse)
Z=0 (along field)
16
15
y 14
13
12
-2
-1
0
1
2
z
x


0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Magnetic Energy Density



Magnetic Energy Density
0.12
0.10
0.08
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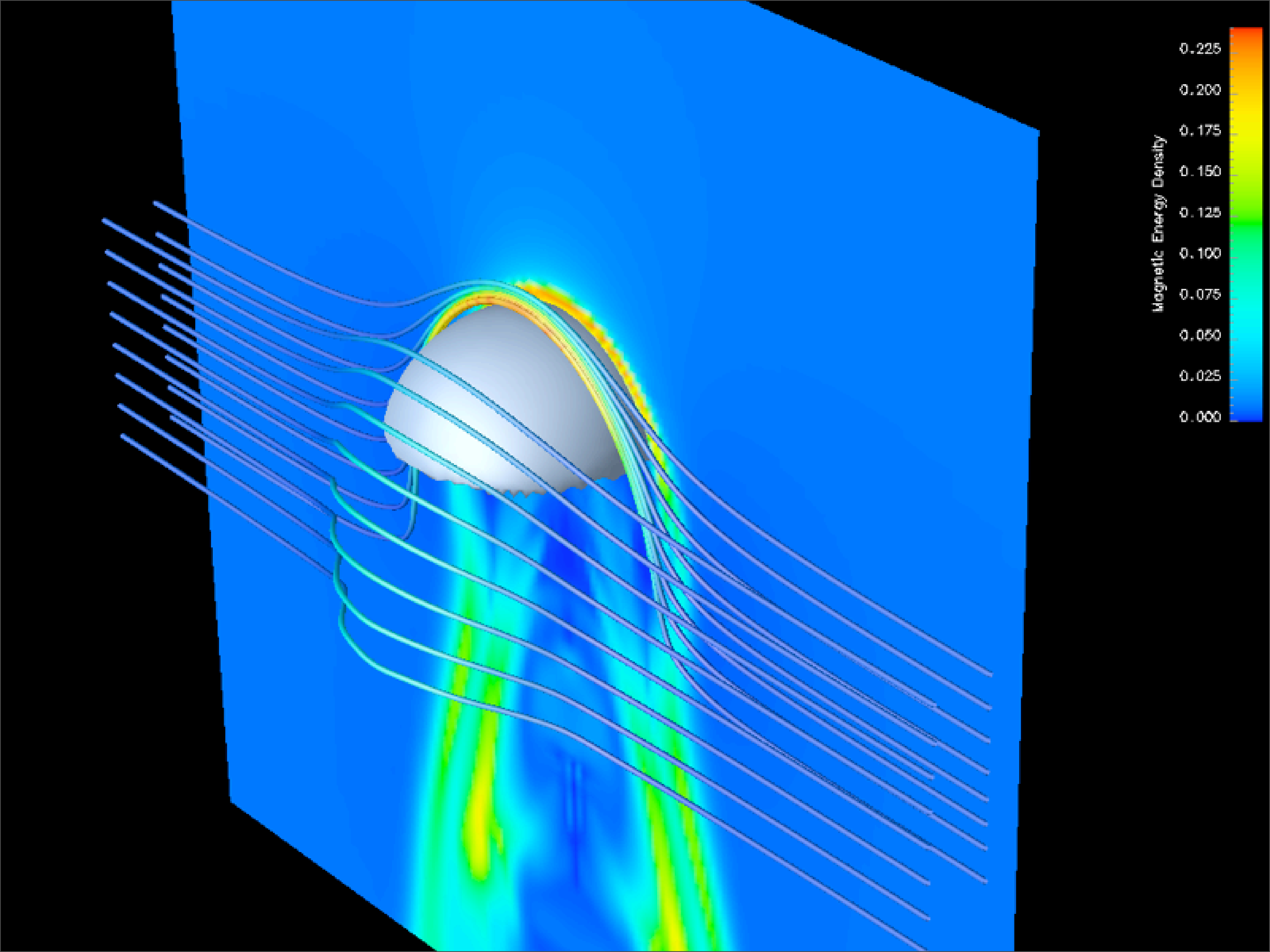
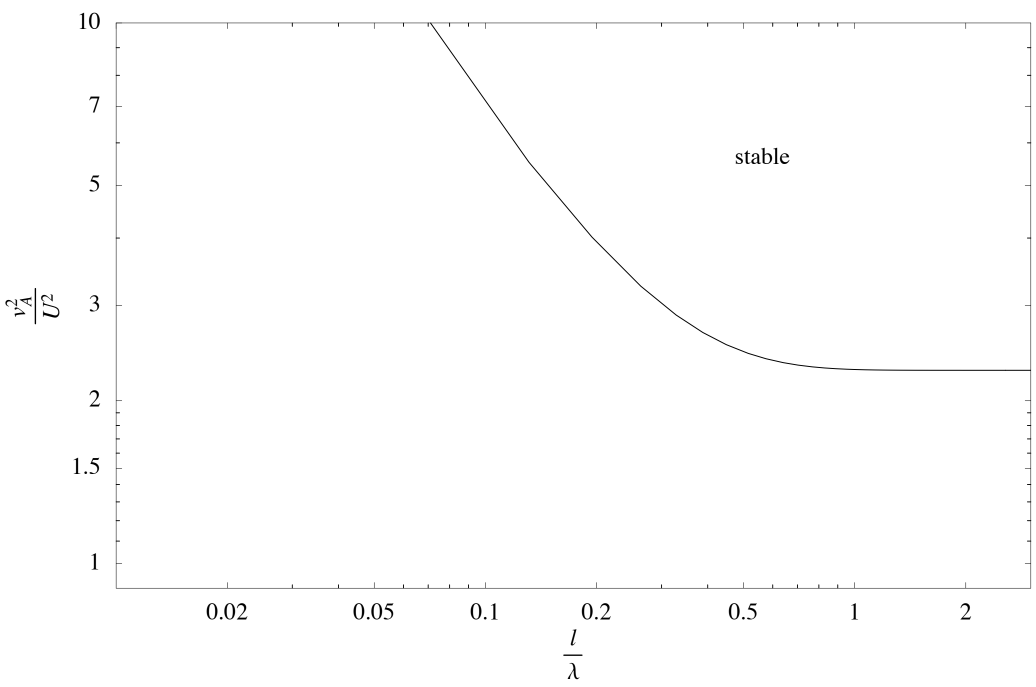
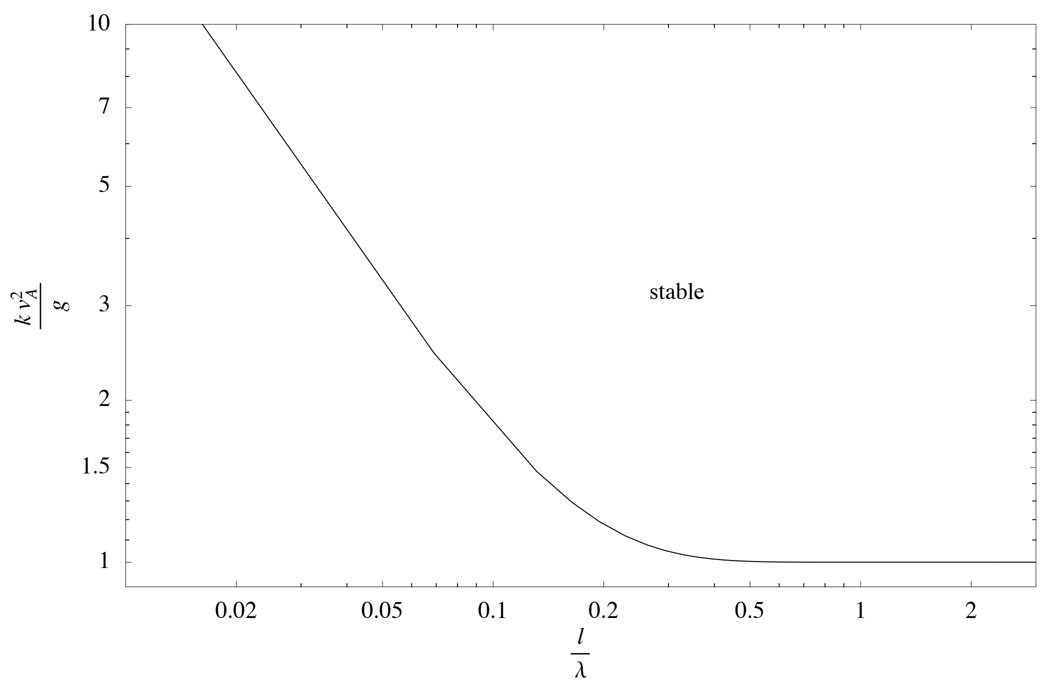
0.02
0.00



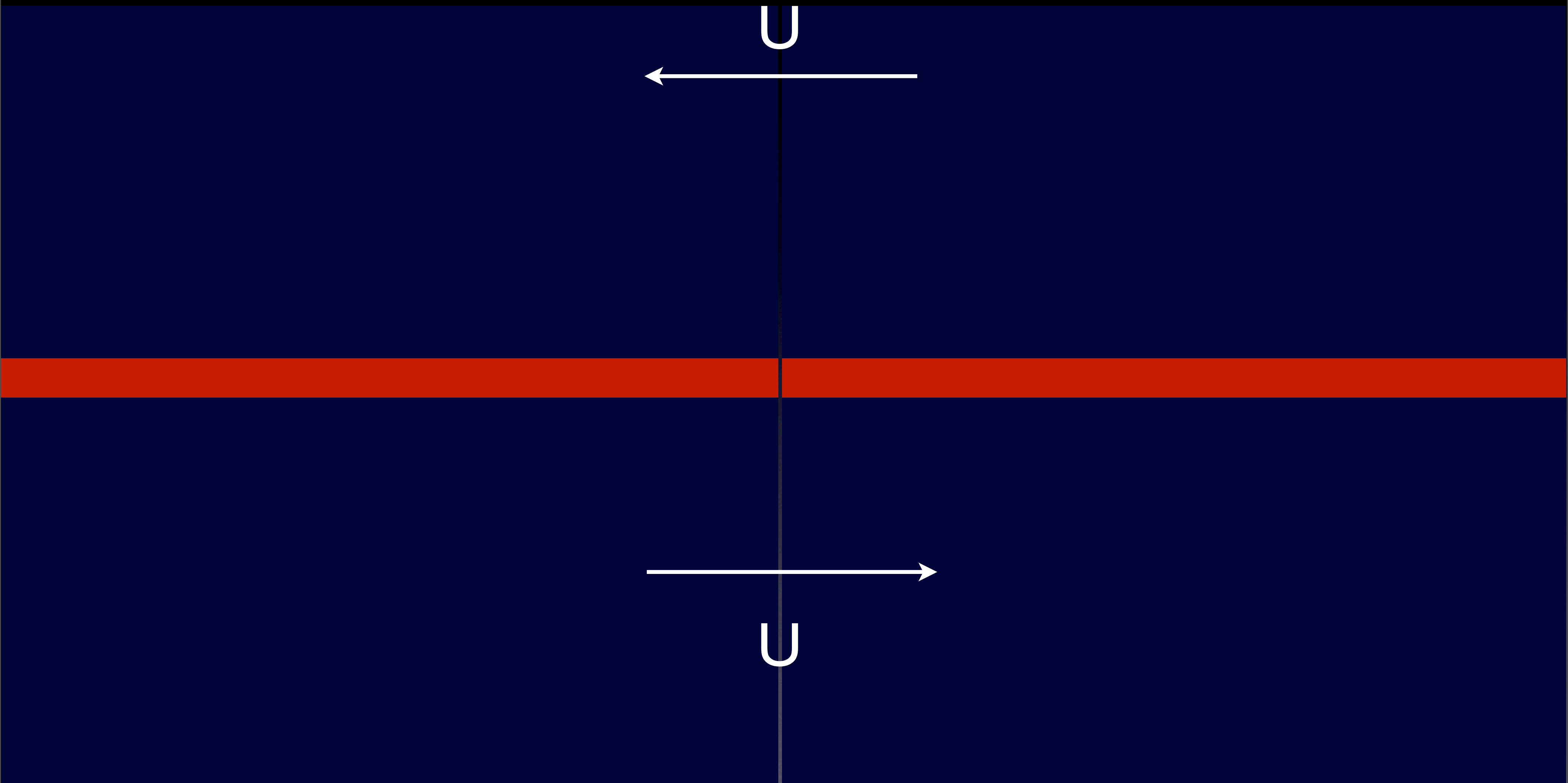
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Magnetic Energy Density





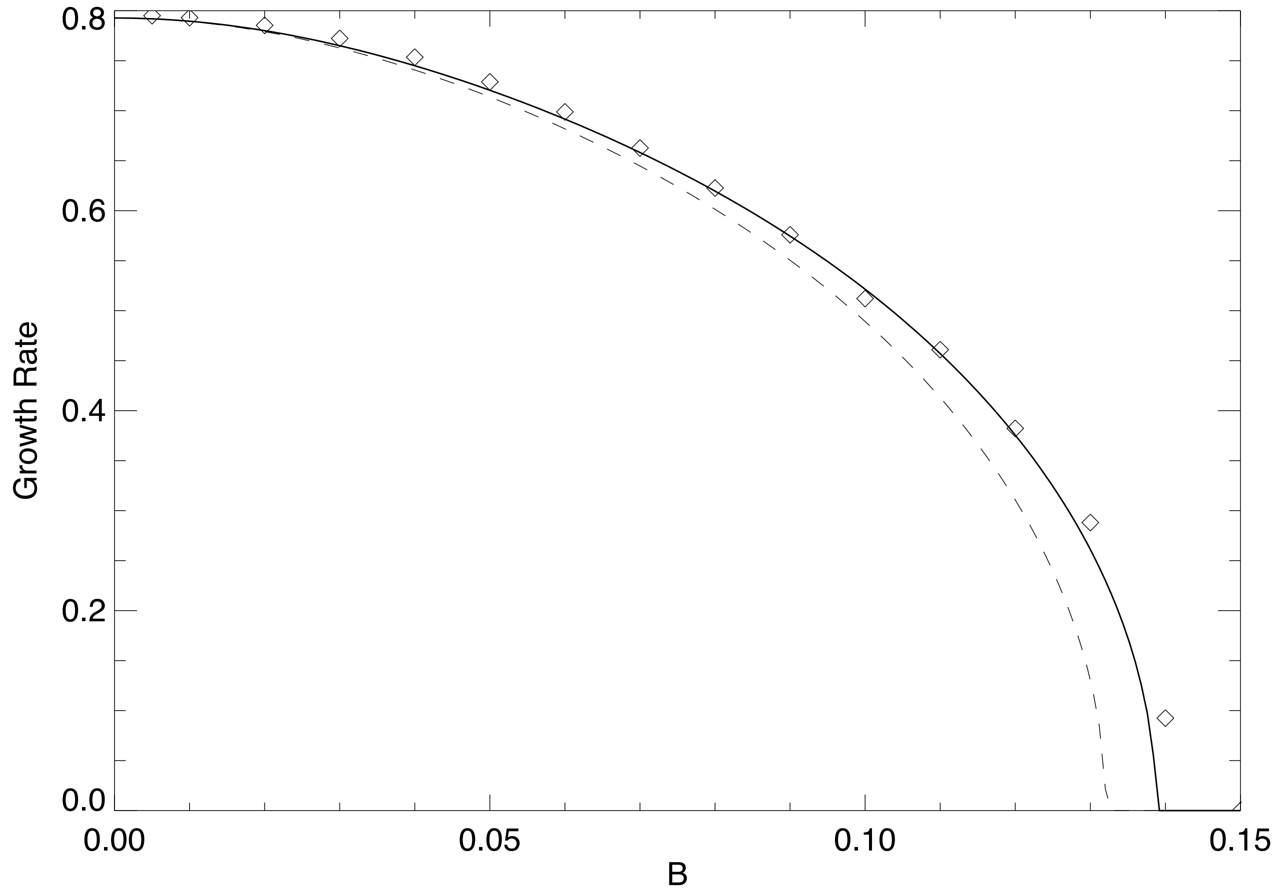
Rayleigh-Taylor

Kelvin-Helmholtz



$V_A = 0.2\ U$

$V_A = 1.25\ U$


0.8
0.6
0.4
0.2
0.0
Growth Rate
0.00
0.05
0.10
0.15
B