

Plazma III

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29. června 2013



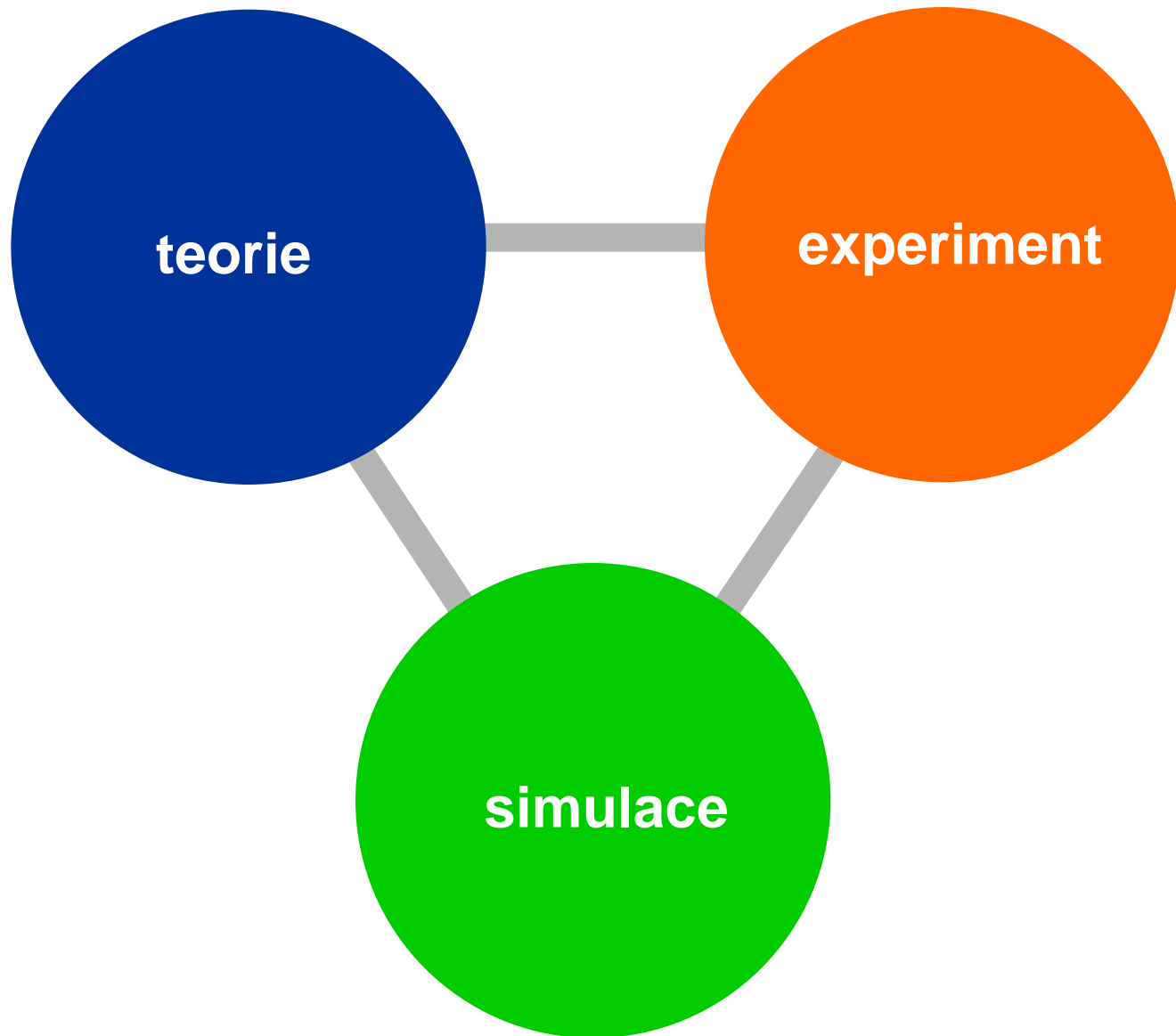
PROGRAM
CEZHRANIČNEJ
SPOLUPRÁCE
SLOVENSKÁ REPUBLIKA
ČESKÁ REPUBLIKA



EURÓPSKA ÚNIA
EURÓPSKY FOND
REGIONÁLNEHO ROZVOJA
SPOLOČNE BEZ HRANÍC



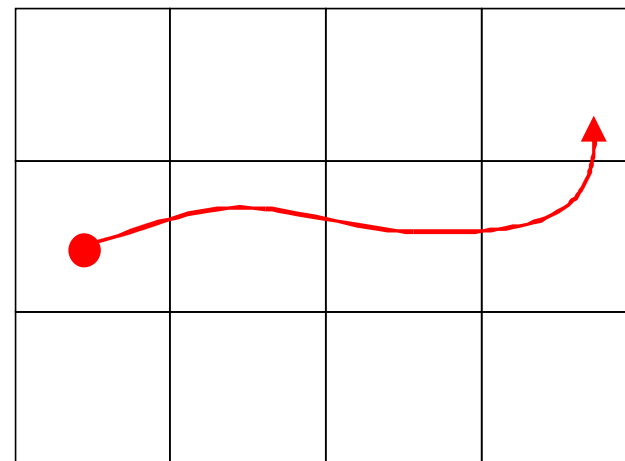
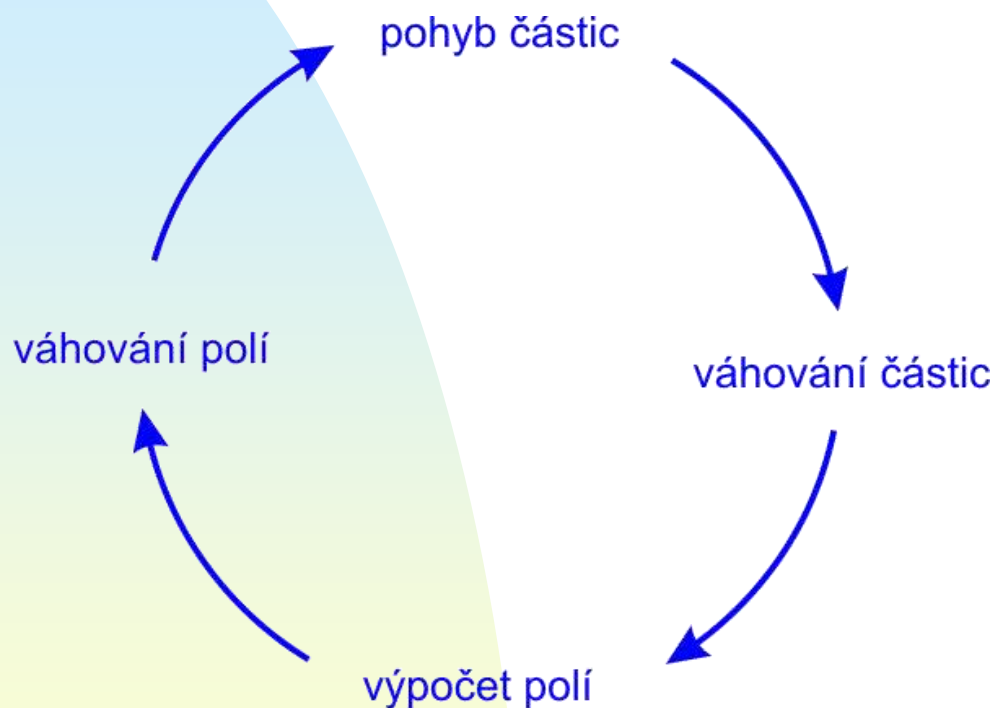
FOND MIKROPROJEKTŮ



Jak popisujeme plazma?

- Pohybové rovnice
 - Maxwellovy rovnice
-
- Částice v poli
 - Molekulární dynamika
 - Magnetohydrodynamika
 - Statistický popis
 - PIC (Particle In Cell)

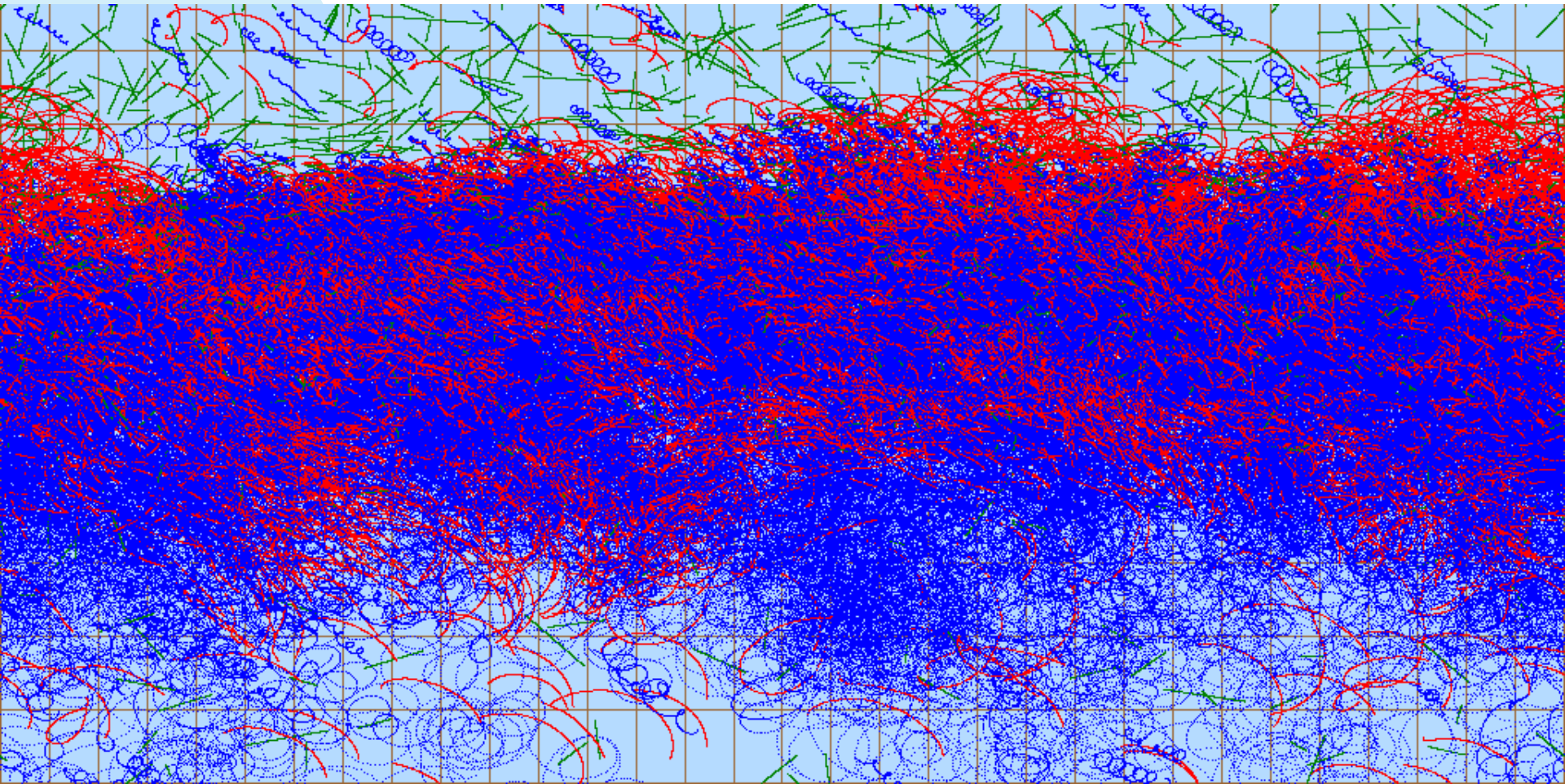
Particle in Cells



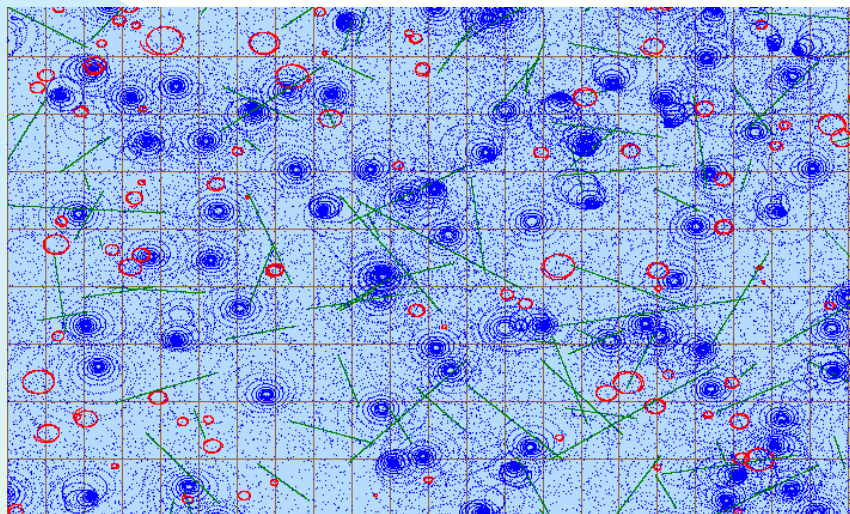
- inicializace
- perturbace
- diagnostika
- vizualizace
- MC srážky
- vyzařování

Particle in Cells

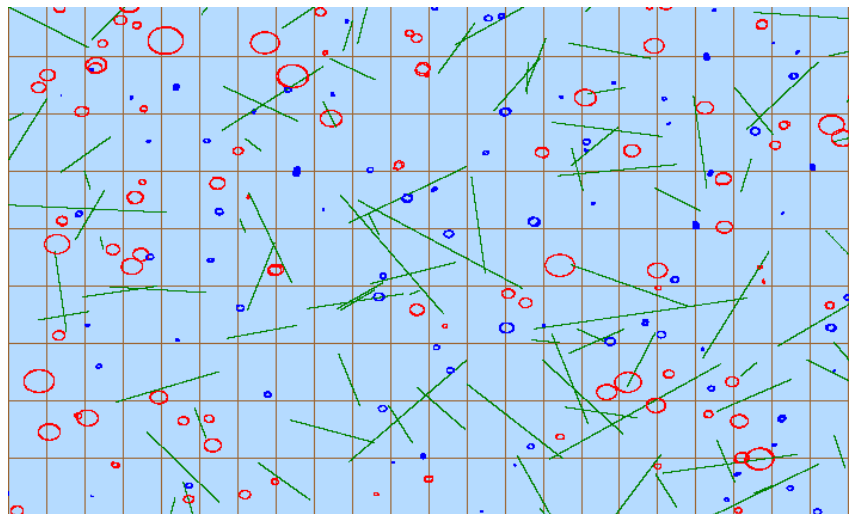
- PP: složitost n^2
- PM: složitost $n \log(n)$
- P: složitost n



Pohyb částic



Newton-Euler



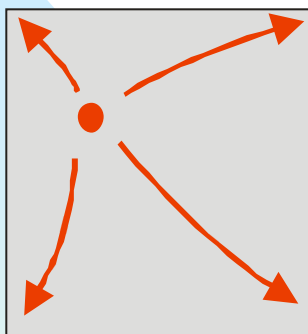
ostatní schémata

50 000 electronů a 50 000 iontů ve
vnějším elektrickém a magnetickém
poli. CPU čas pro 200 časových
kroků (PC, Celeron 333 MHz)

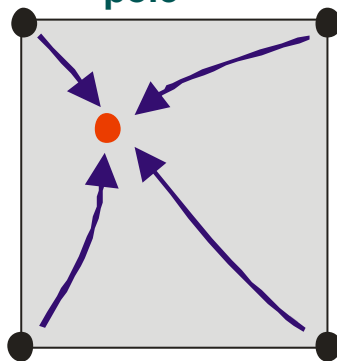
Schéma	nerelativistcké	relativistické
Newton-Euler	14.8	33.5
Leapfrog	38.5	92.0
Runge-Kutta 4 th order	25.6	44.7
Boris-Buneman	21.5	45.7
Kanonické	17.4	42.1

Váhování

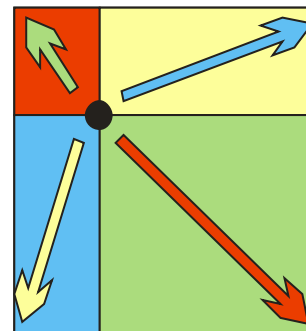
částice



pole



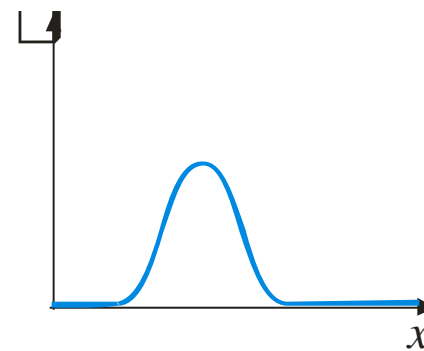
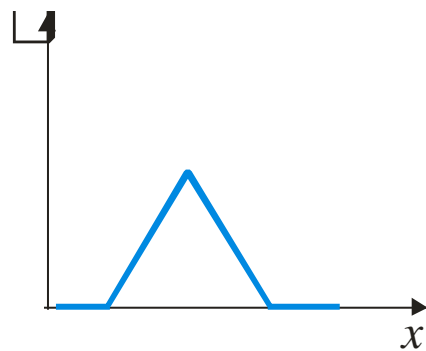
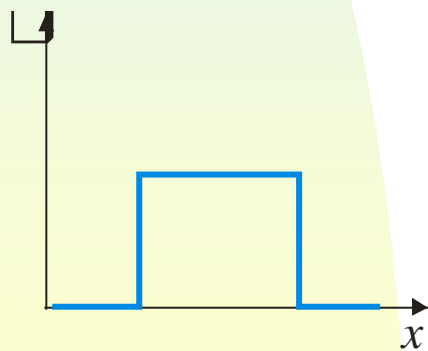
A



B

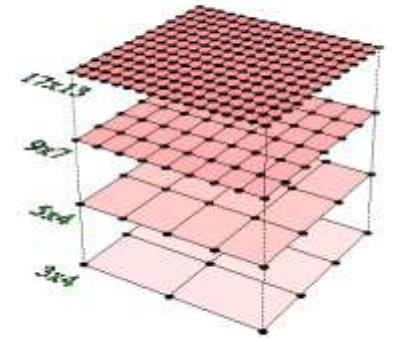
C

D

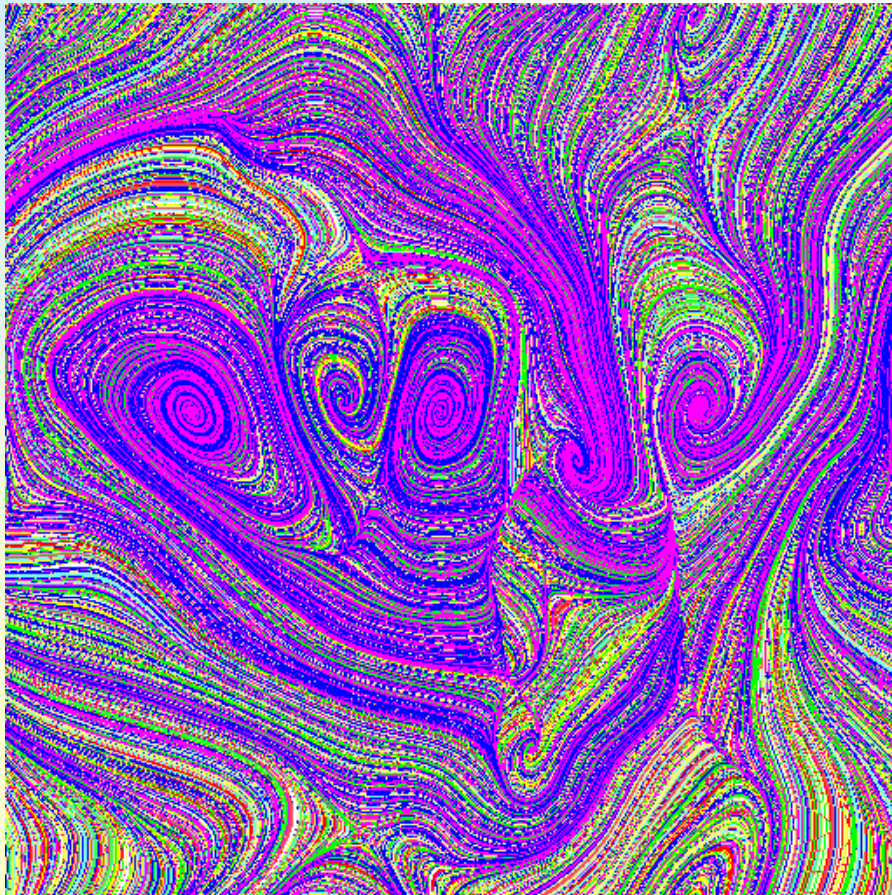


Řešení polí

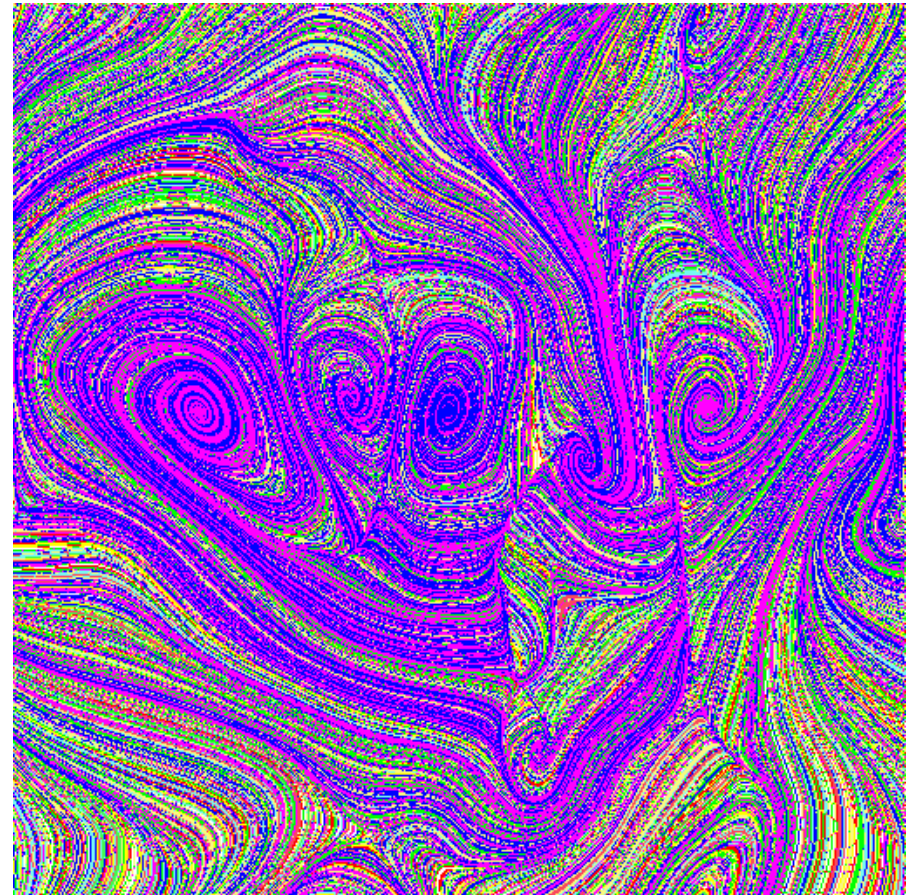
- FFT (Radim Dejmek)
- MUDPACK (US Nat. Center for Atmospheric Research)



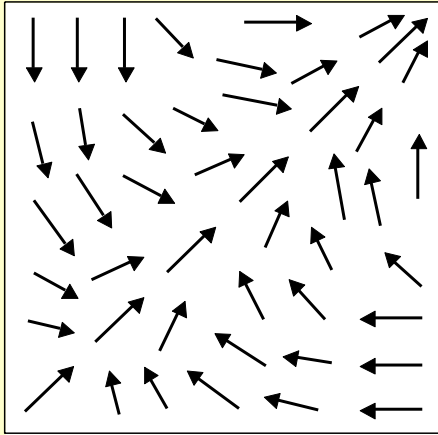
FFT



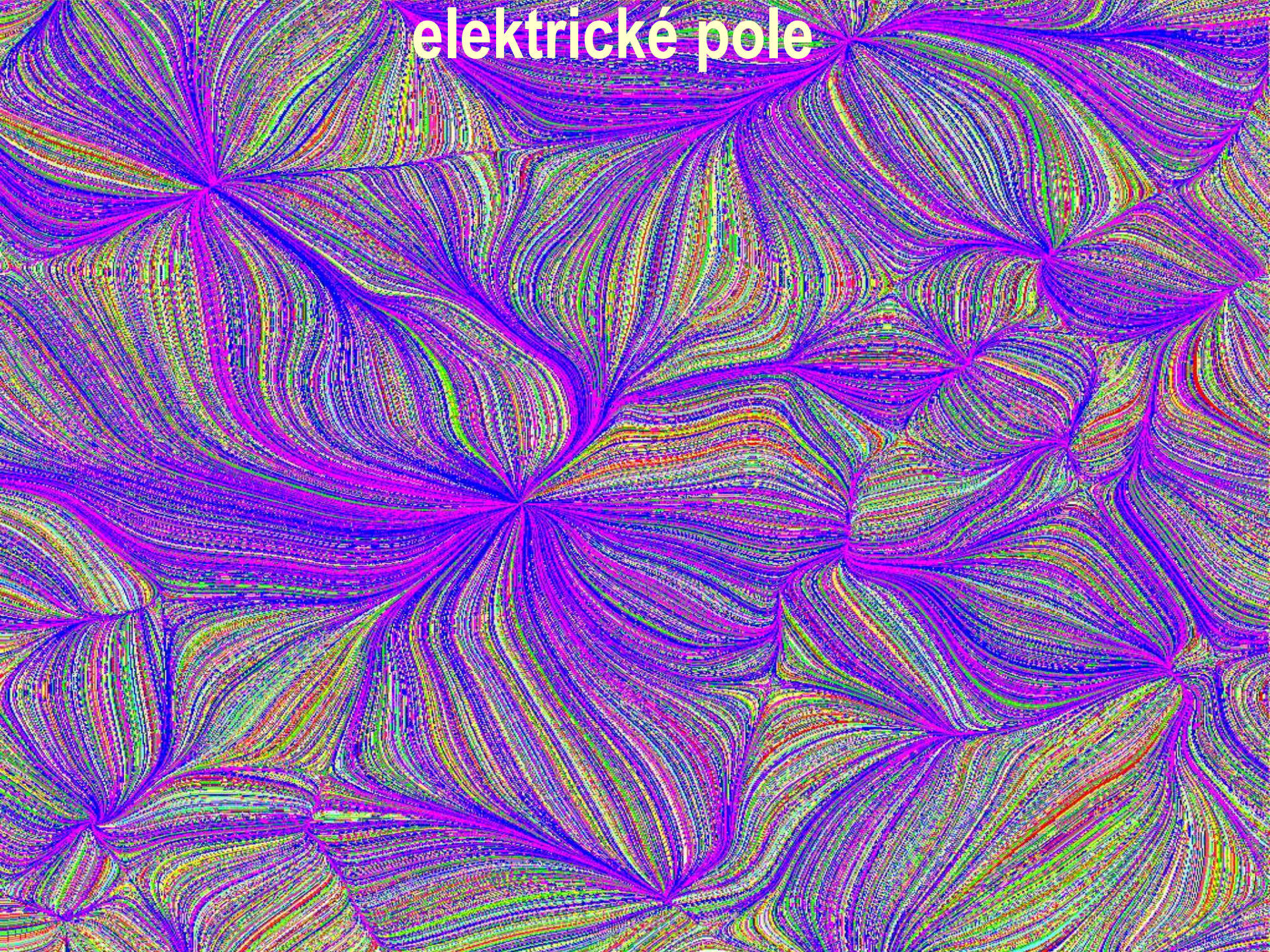
MUDPACK



Vizualizace polí (LIC)



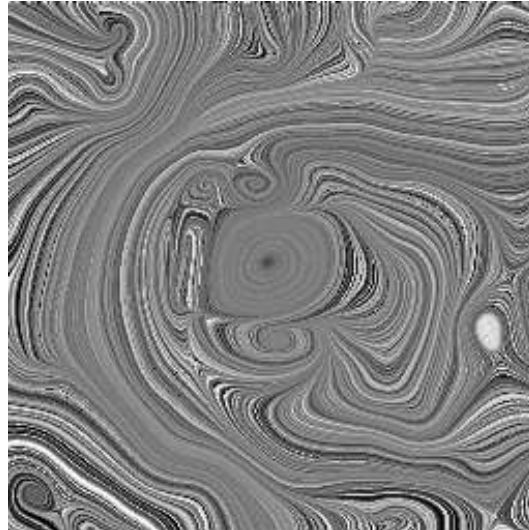
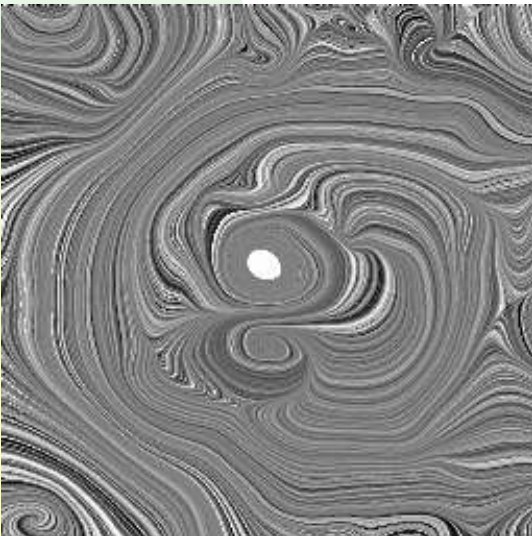
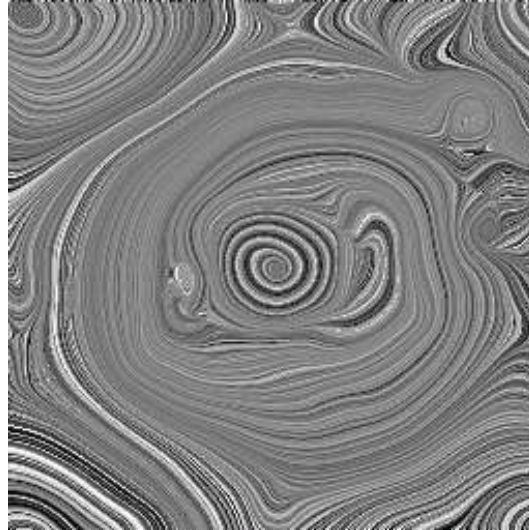
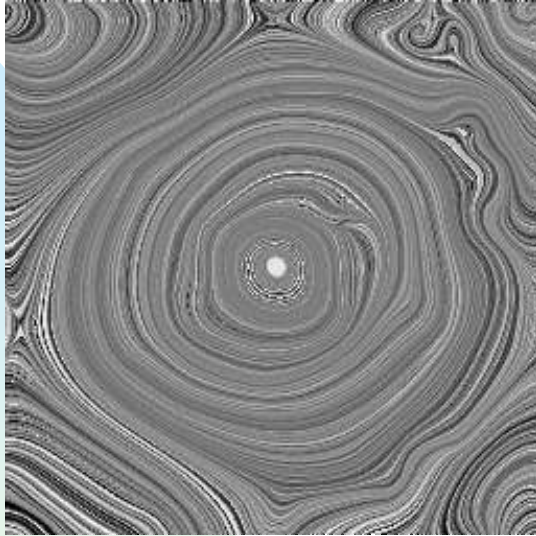
elektrické pole



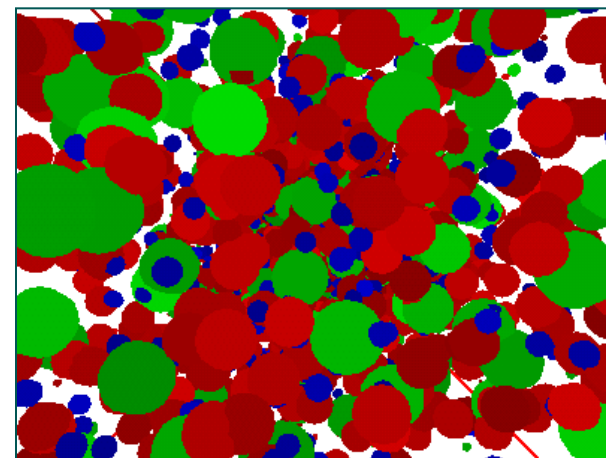
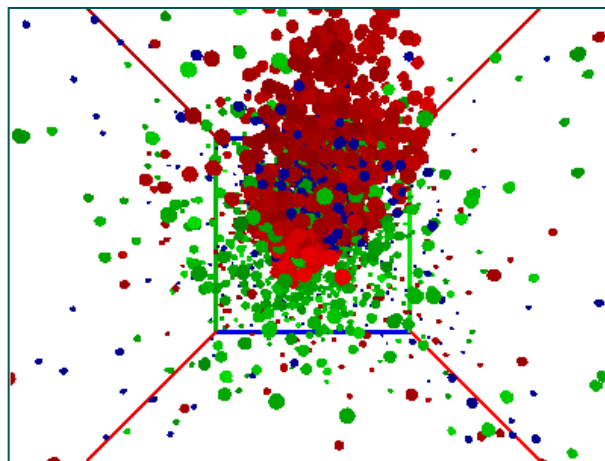
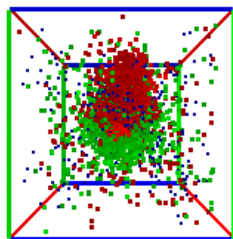
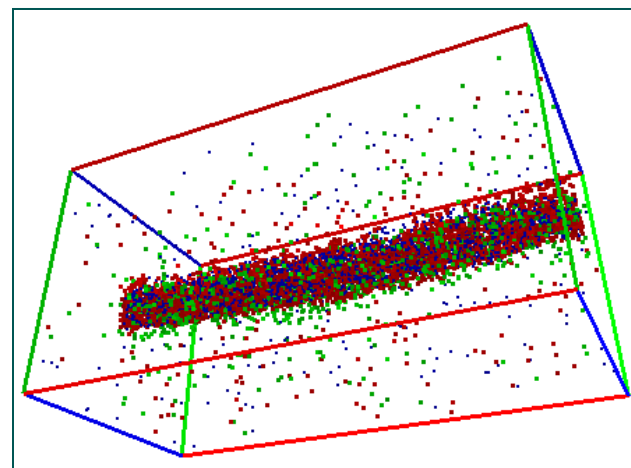
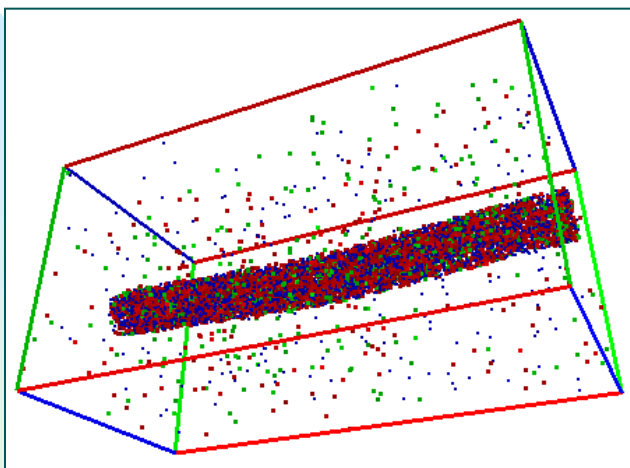
magnetické pole



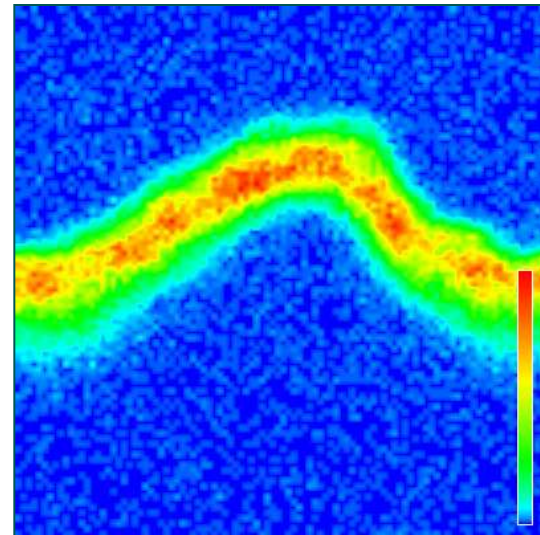
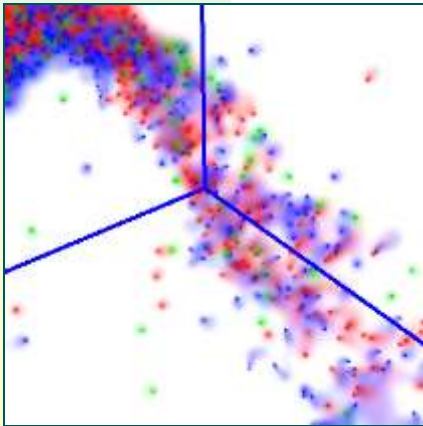
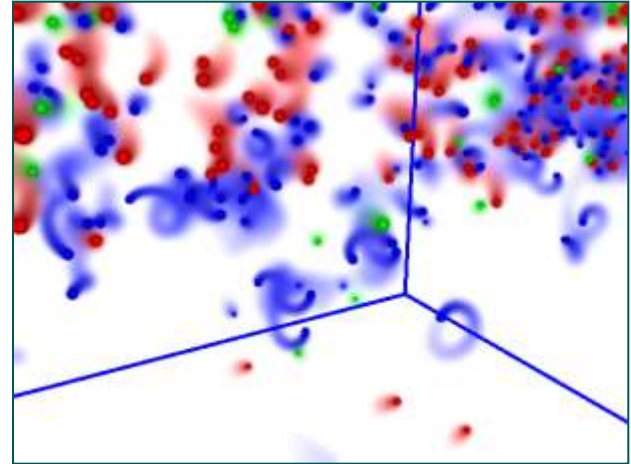
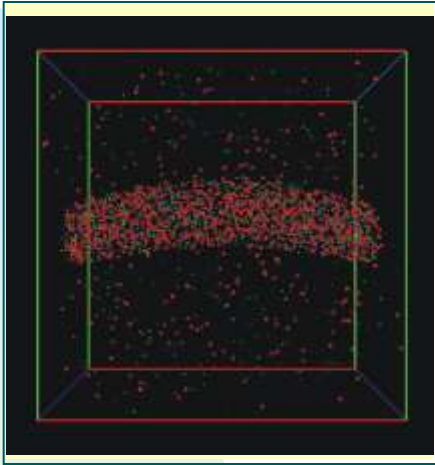
Časový vývoj vláknna



Vizualizace částic



Vizualizace částic



GUI

PIC parameters

Particle solver
☐ Newton
☐ Runge Kutta
☒ Leap Frog
☐ Buneman
☐ Canonical

Field solver
☒ FFT
☐ Multigrid

Weighting
☐ 0
☒ 1

Model input
☒ Background
☒ Beam R
☐ Beam L
☒ e
☒ i
☒ n
☒ e
☒ i
☒ n
☐ e
☐ i
☐ n
Beam diameter (%)

Model output
☒ Diagnostics # steps/diag
☐ Visualiz. File # steps/snap
☐ Radiation File # steps/rad
☐ Bitmap File # steps/bmp

Particle parameters: Q/Qe, M/Me, N, T[eV]
Qe Qi Qn
Me Mi Mn
Te Ti Tn
Ne Ni Nn

Beam parameters
Ve Vi Vn
Te Ti Tn
Ne Ni Nn

External nondimensional fields E, B
Ex Ey Ez
Bx By Bz

Grid: size L/X0, granularity G (integer 1...8)
Lx Ly Lz
Gx Gy Gz

Perturbation
☐ Sausage
☒ Kink
☐ Radial Field
☐ Axial Current
 Magnitude

Draw
☐ PIC redraw
☒ Grid
☐ Electric field
☐ Magnetic field
☒ Plane (x,y)
☐ Plane (y,z)
☐ Plane (z,x)

total steps

OK

Diagnostics

Average values
☒ Velocity
☐ Current density
☒ Polarization
☐ Magnetization
☐ Electric field
☒ Magnetic field

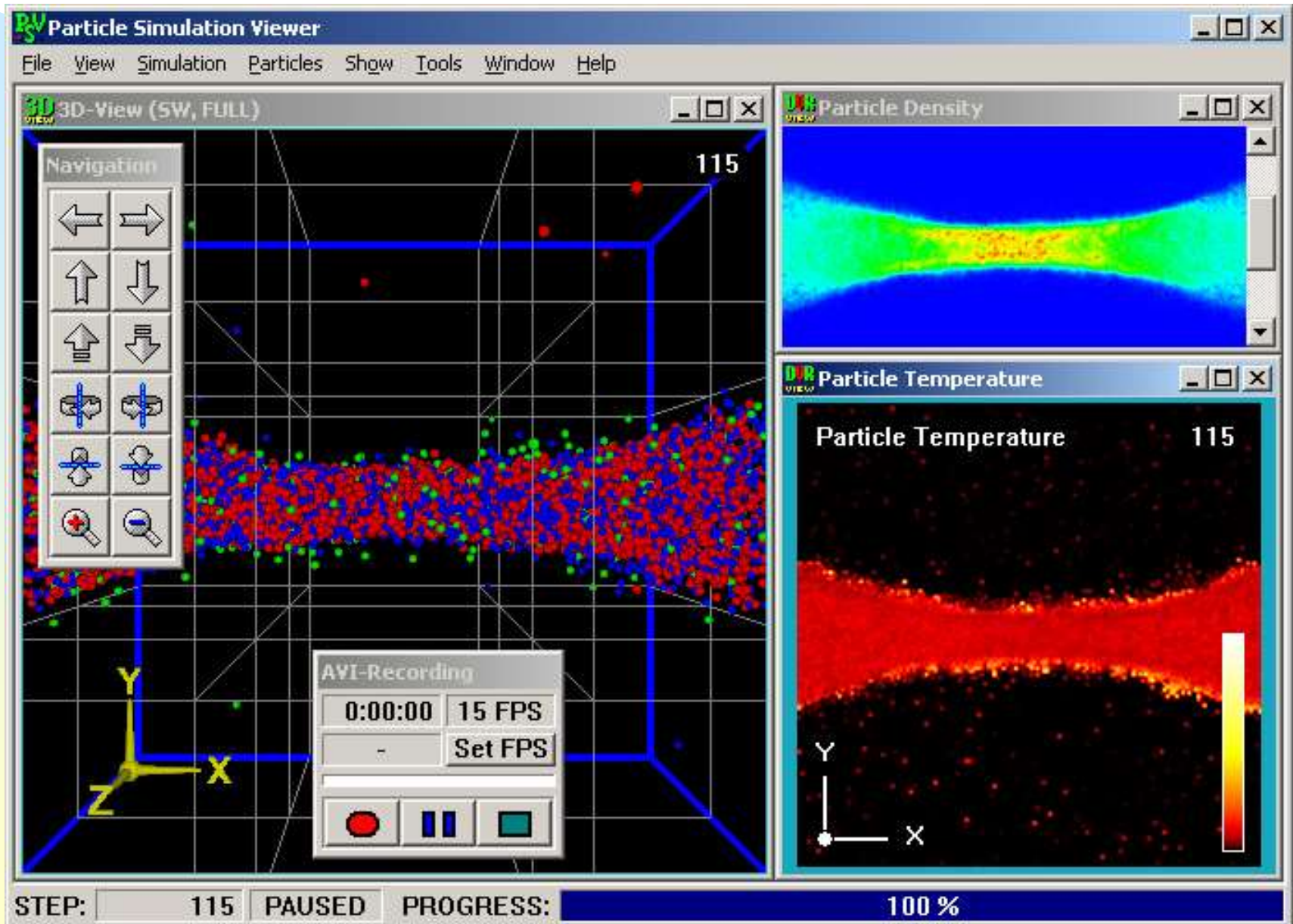
Variances
☐ Velocity
☐ Current density
☒ Polarization
☐ Magnetization
☐ Electric field
☐ Magnetic field

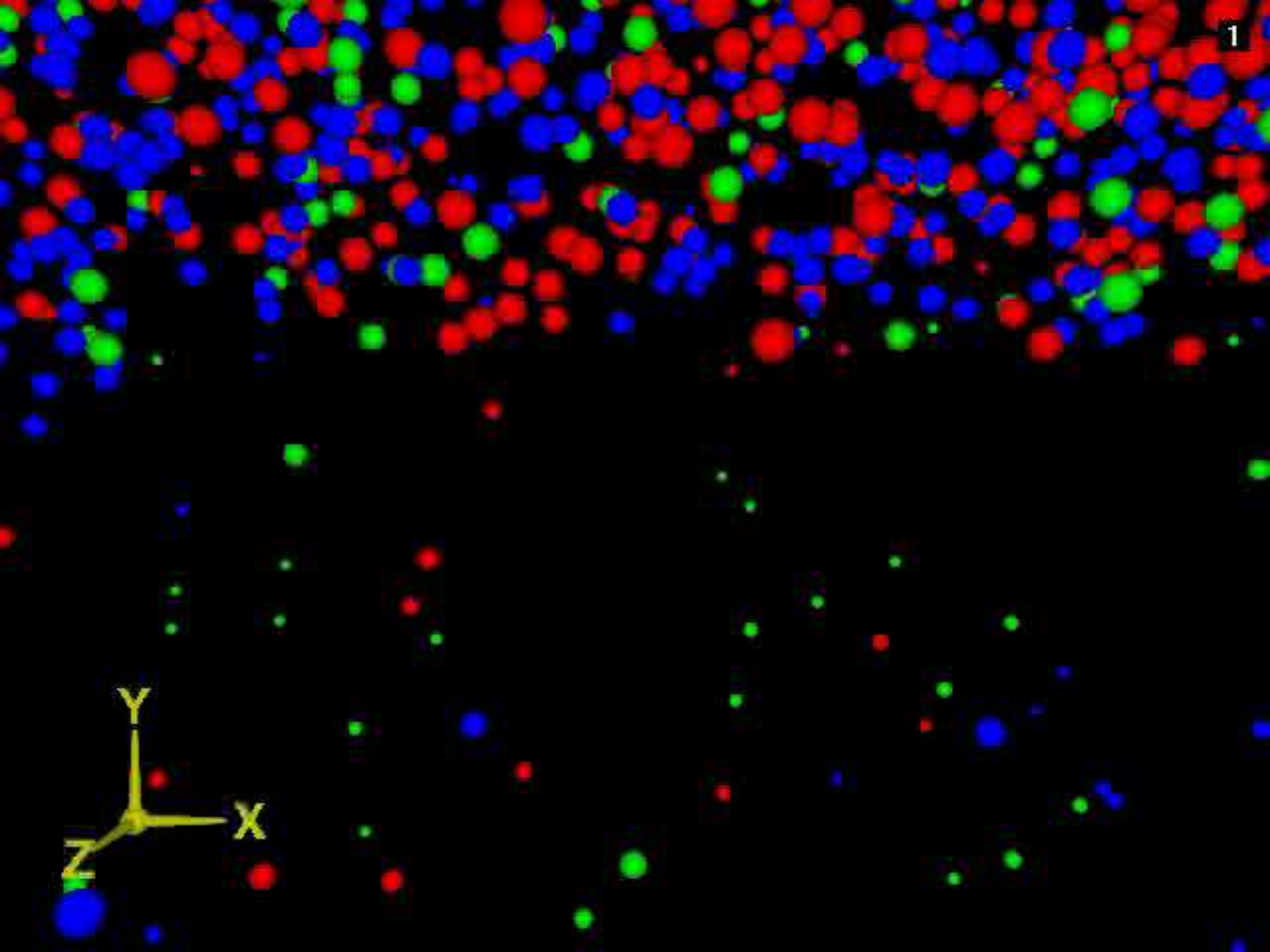
Phase Diagram
☒ Phase Diagram
☒ Electrons
☒ Ions
☐ Neutrals
X: ☐ x ☒ y ☐ z
Y: ☒ vx ☐ vy ☐ vz

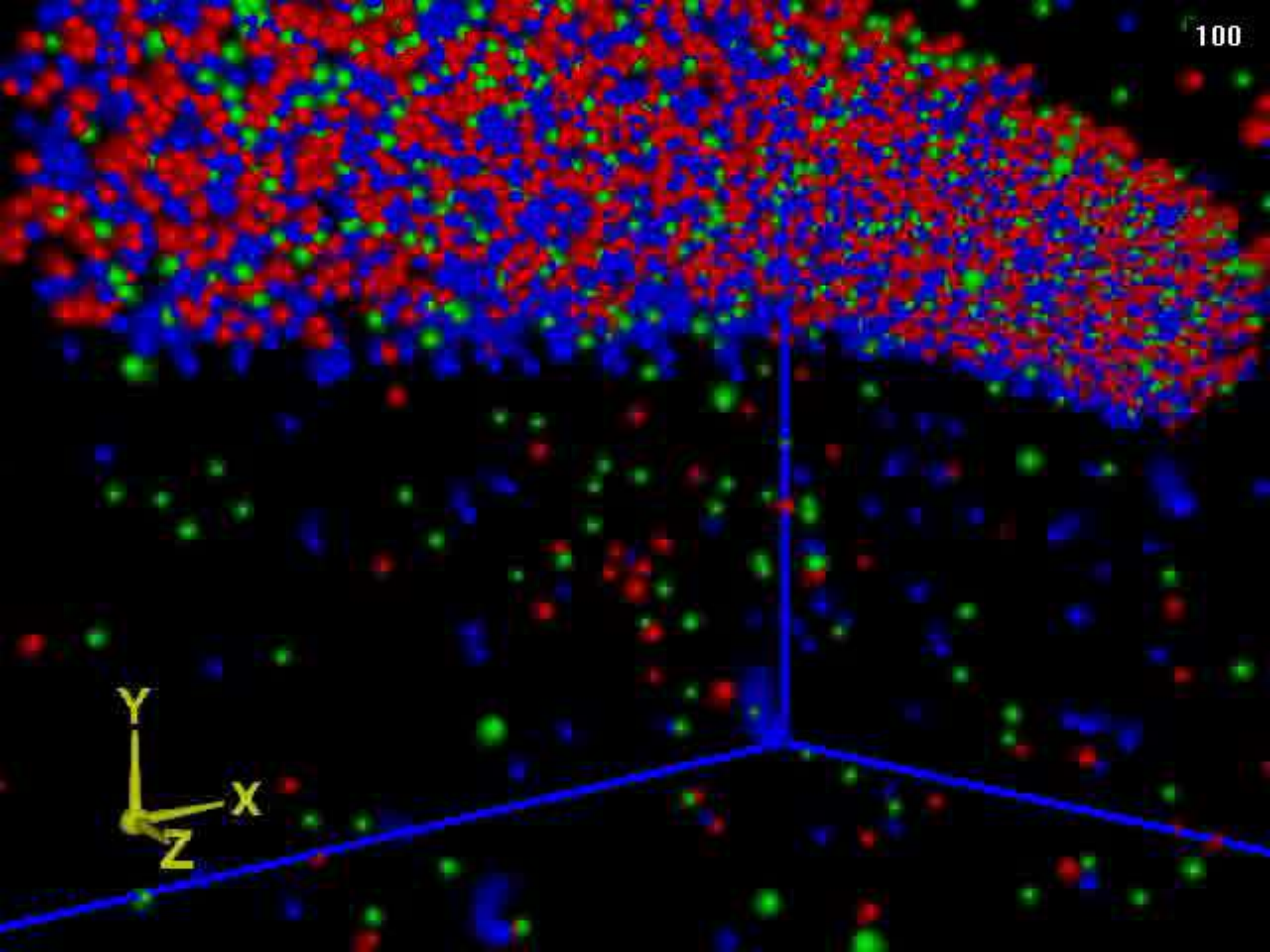
☒ Save results as bitmap files

OK

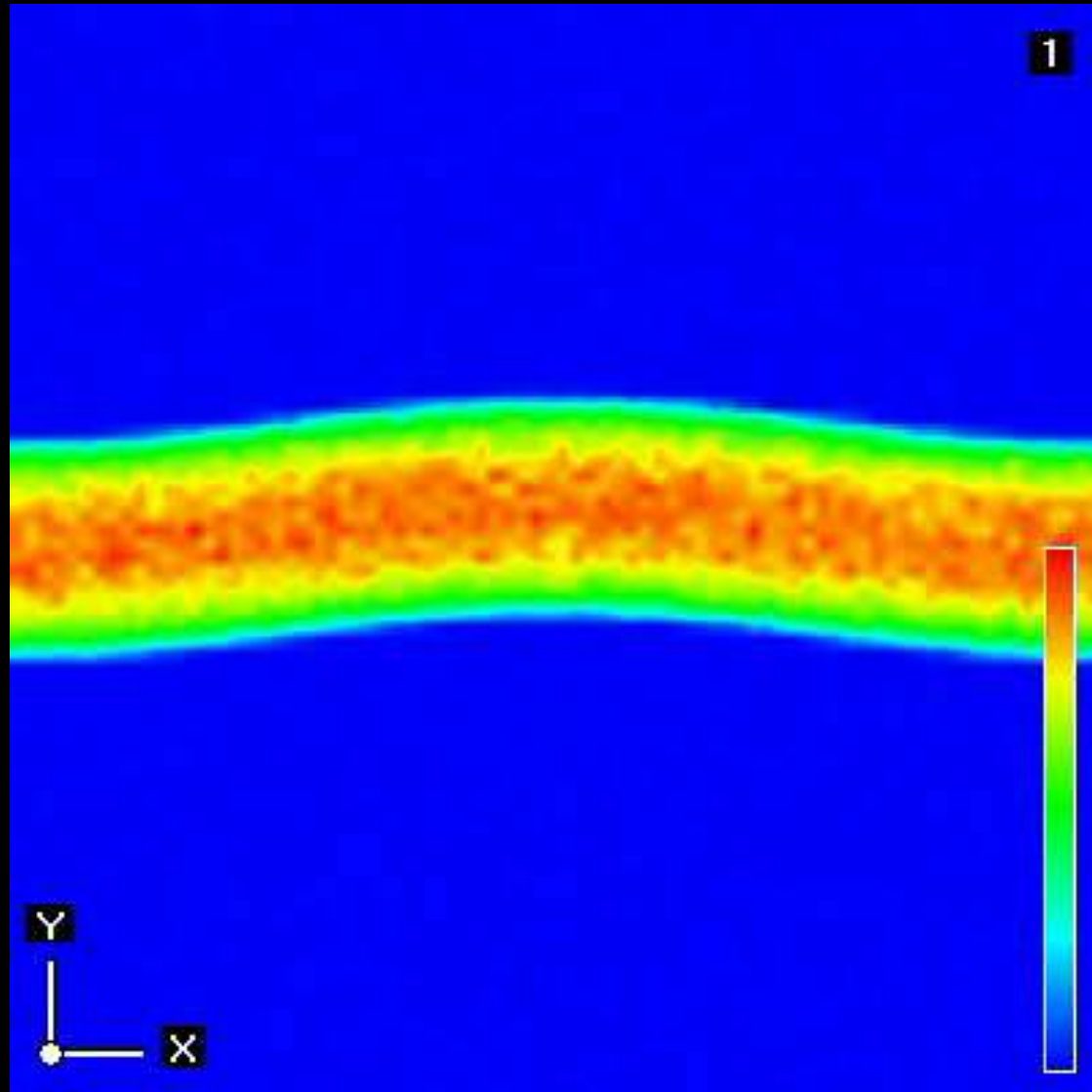
GUI



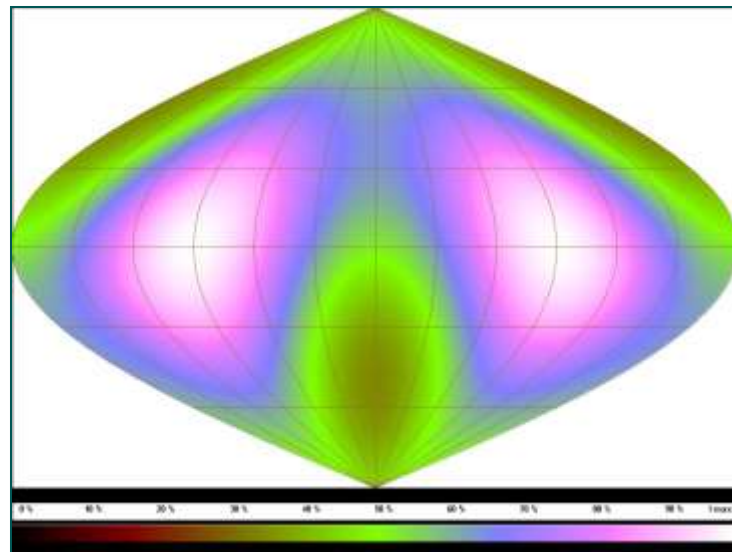
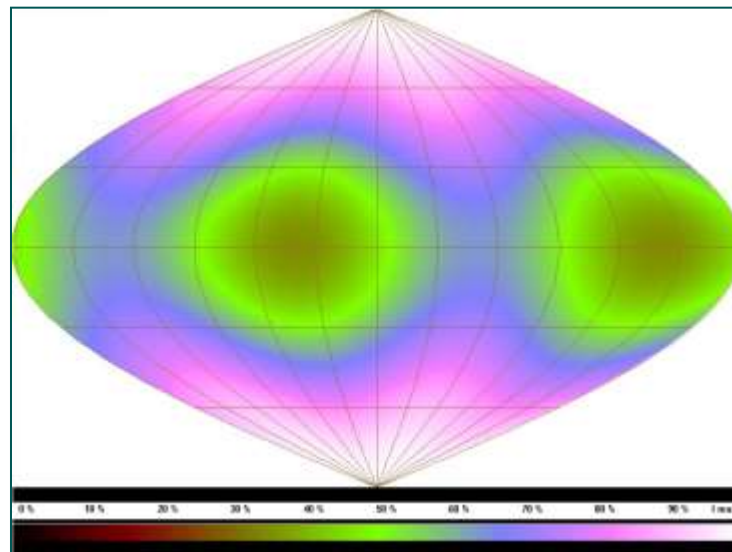
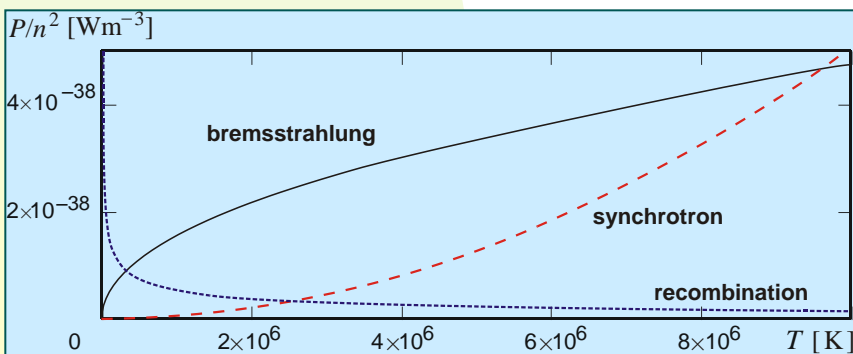
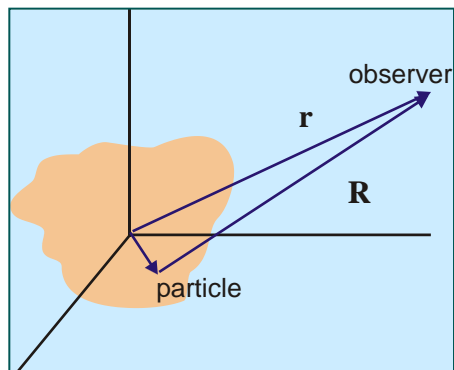
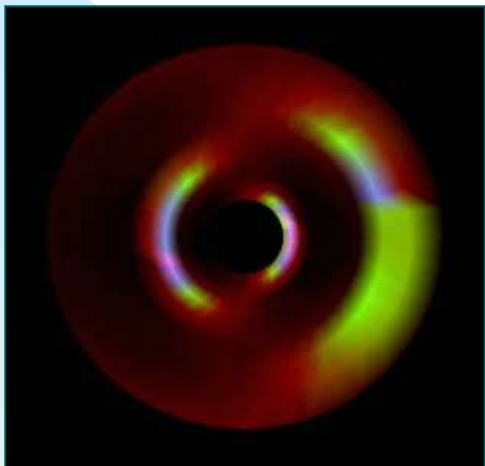


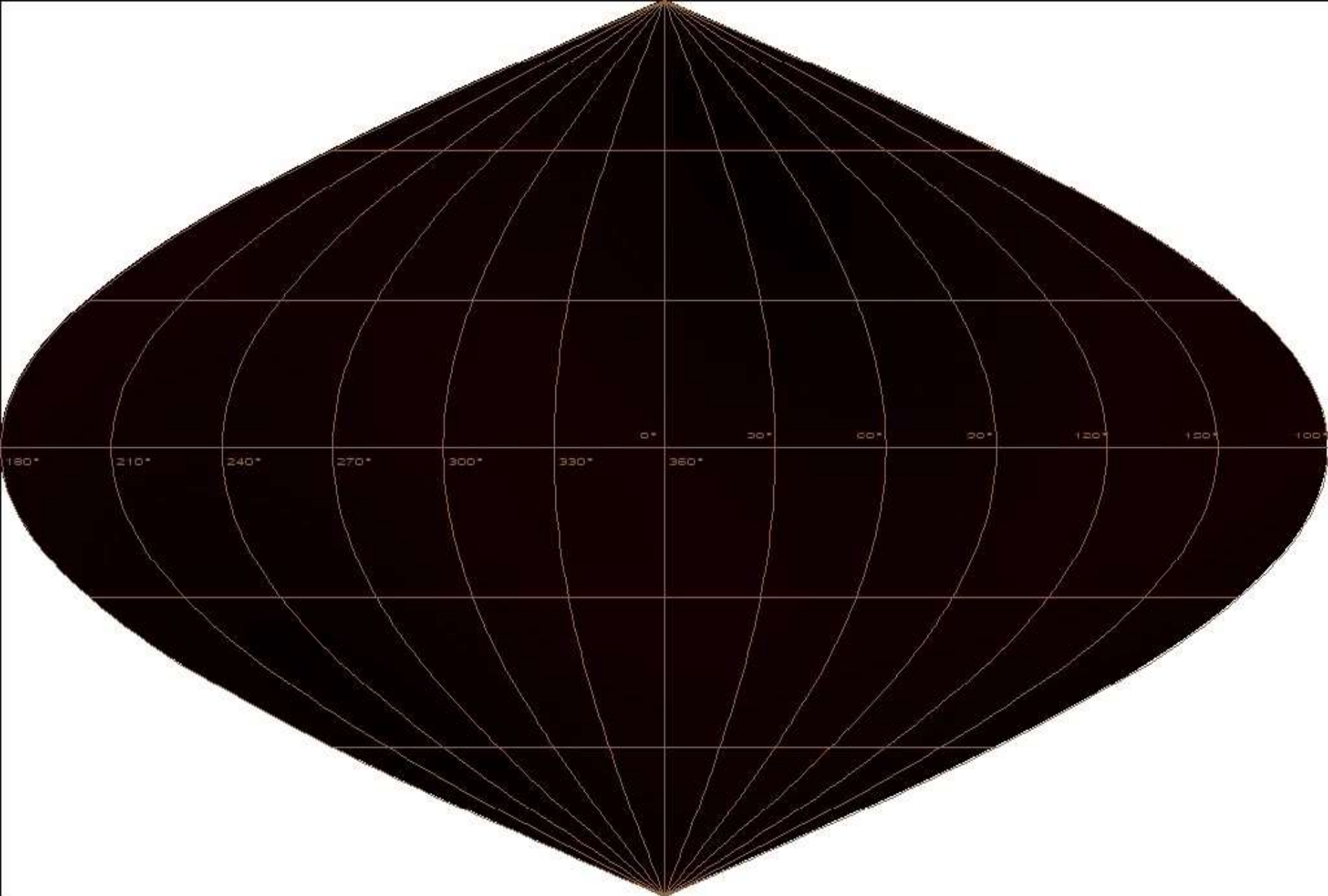


PIC



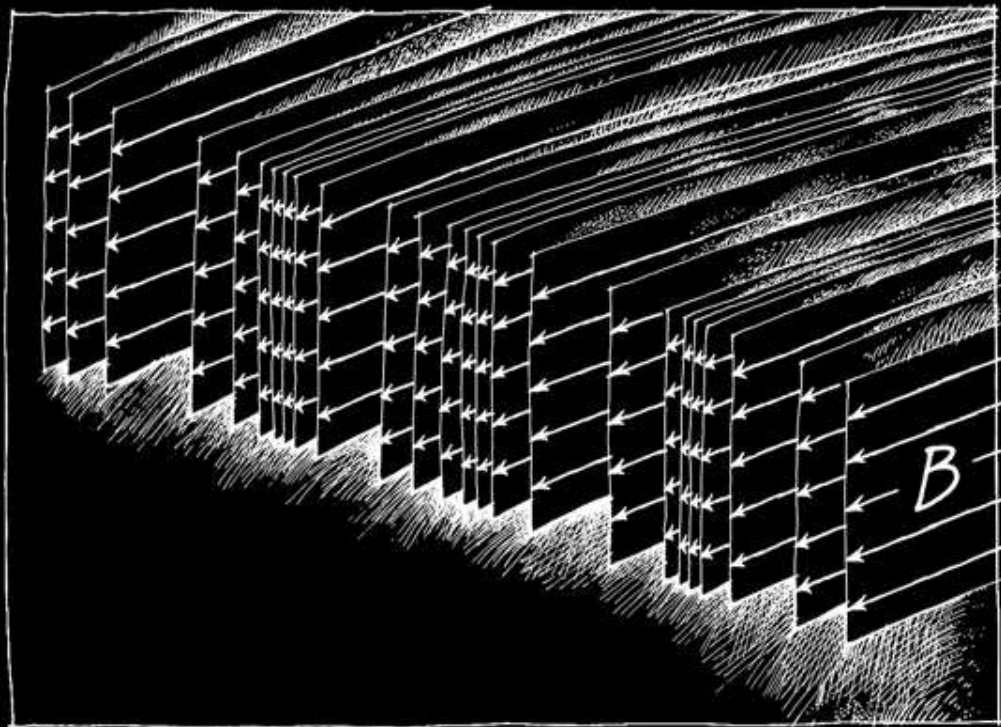
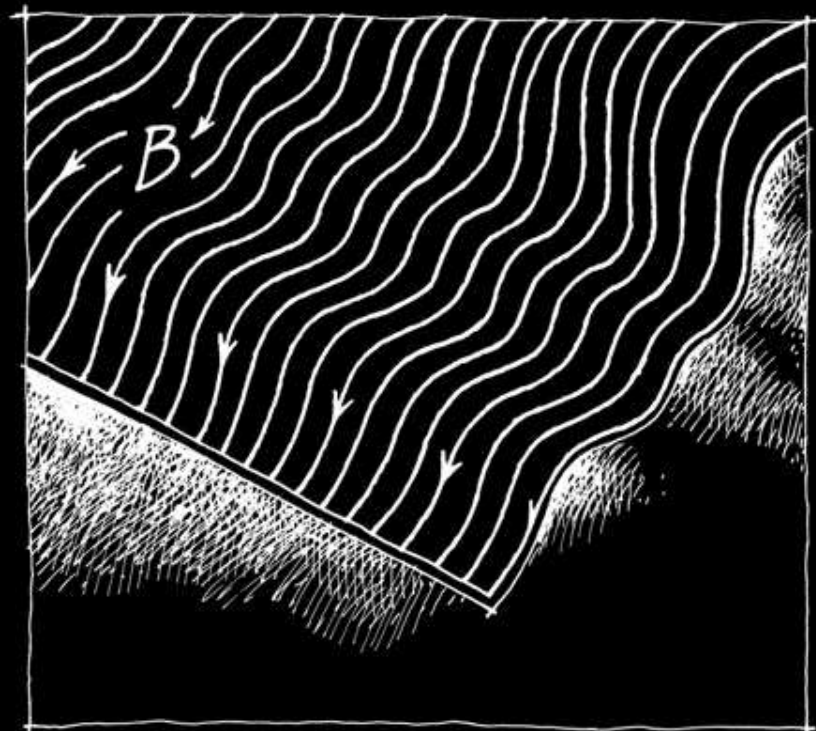
Vyzařování



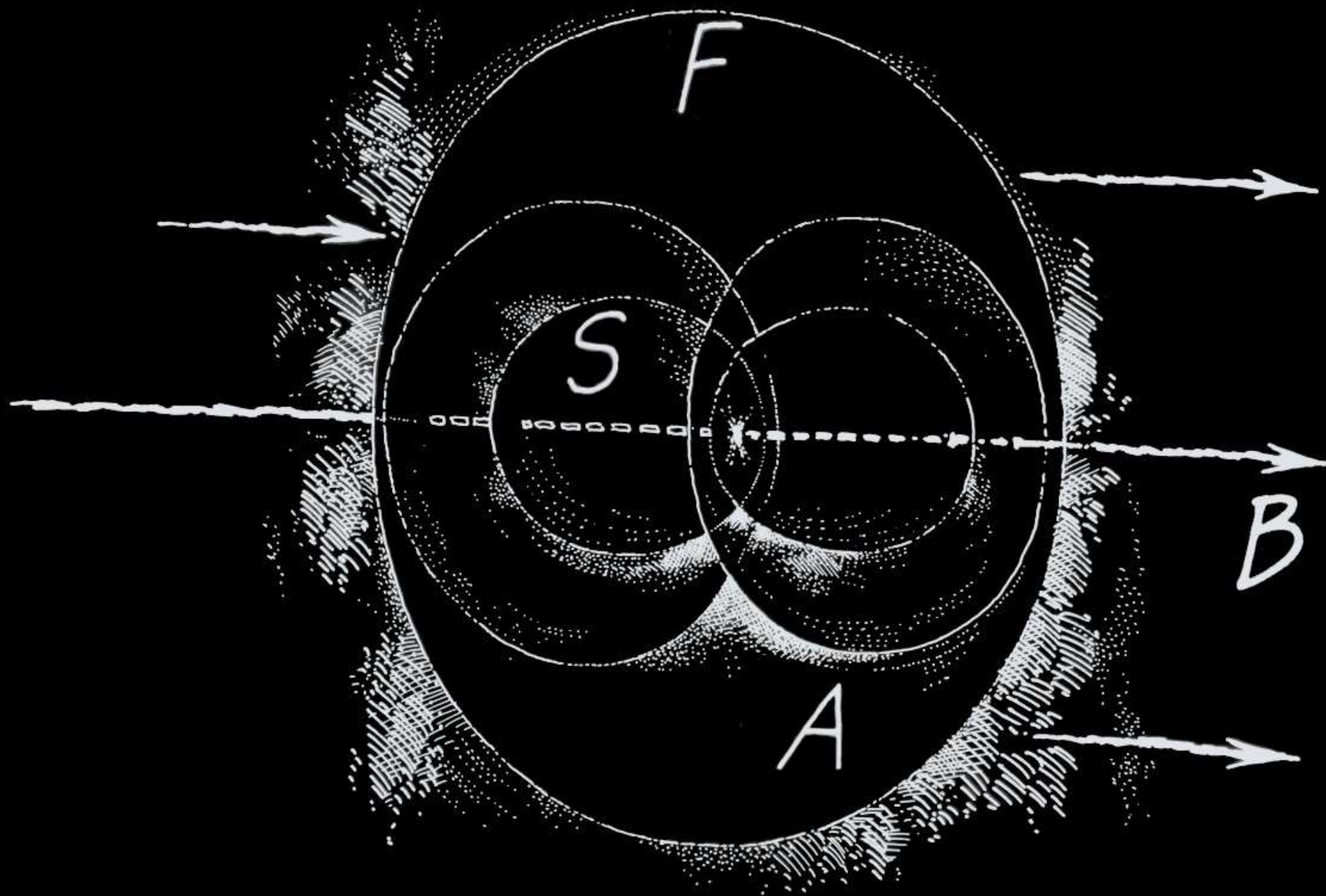


0 % 10 % 20 % 30 % 40 % 50 % 60 % 70 % 80 % 90 % 1 max

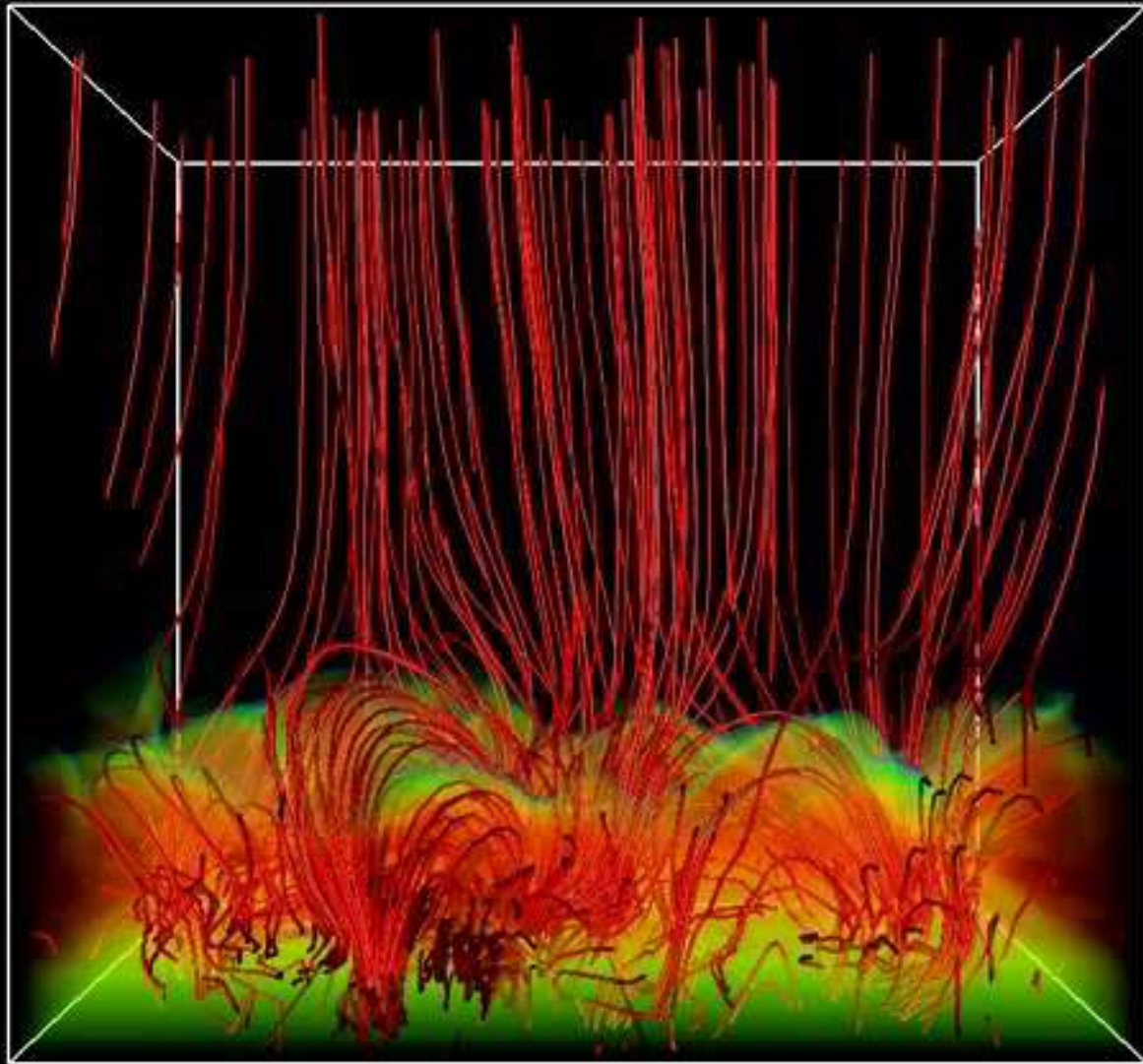




Magnetoakustický komplex

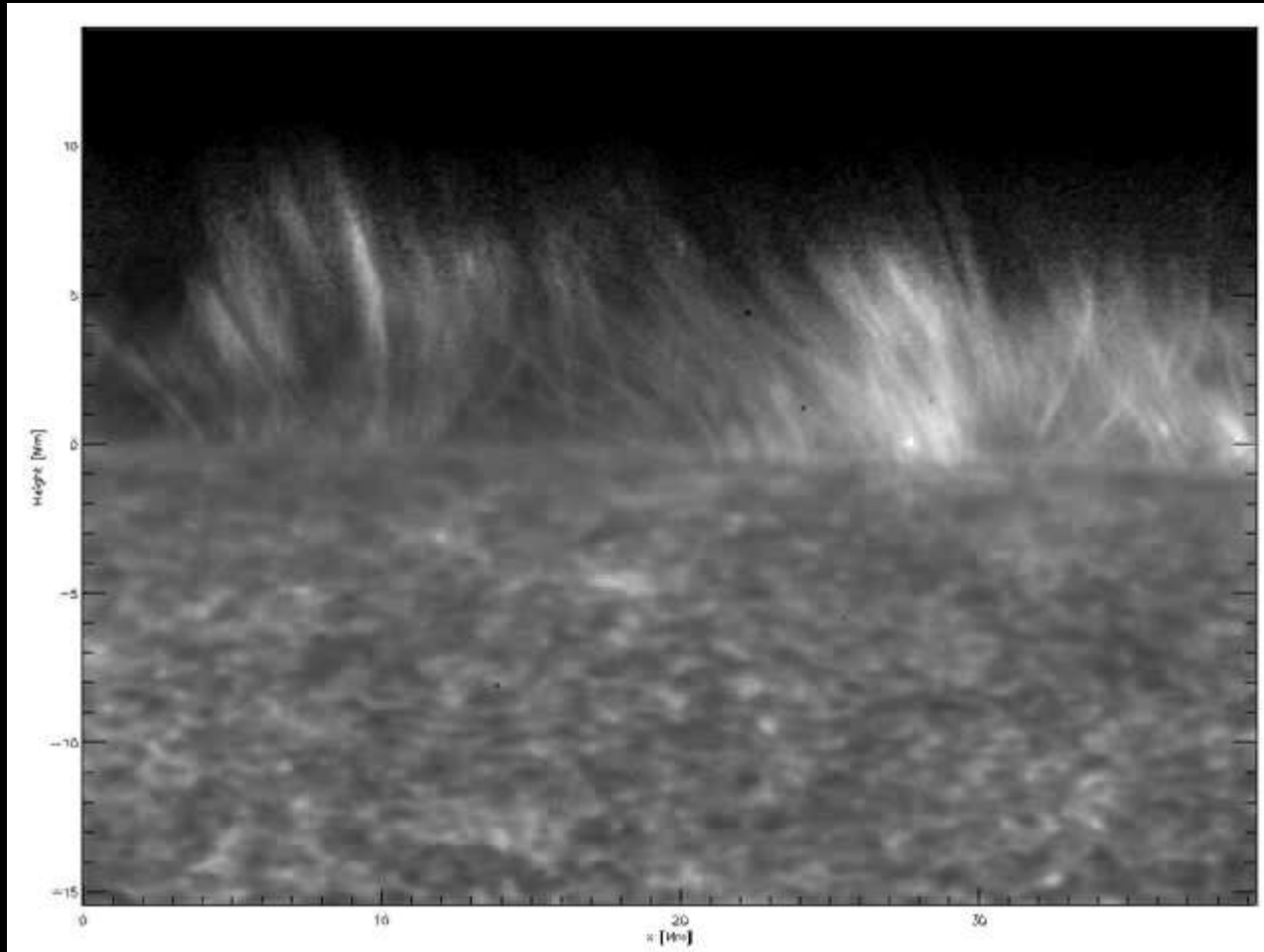


Alfvénova vlna



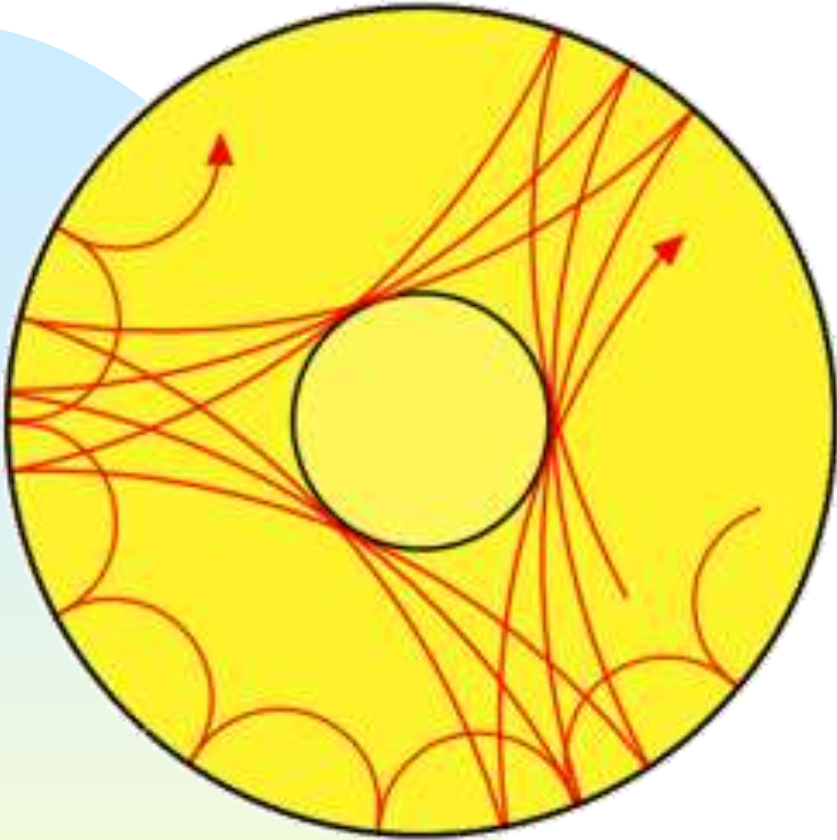
Institute for Theoretical Astrophysics, University of Oslo

Hinode (Solar B), agentura JAXA, Japonsko, 2006

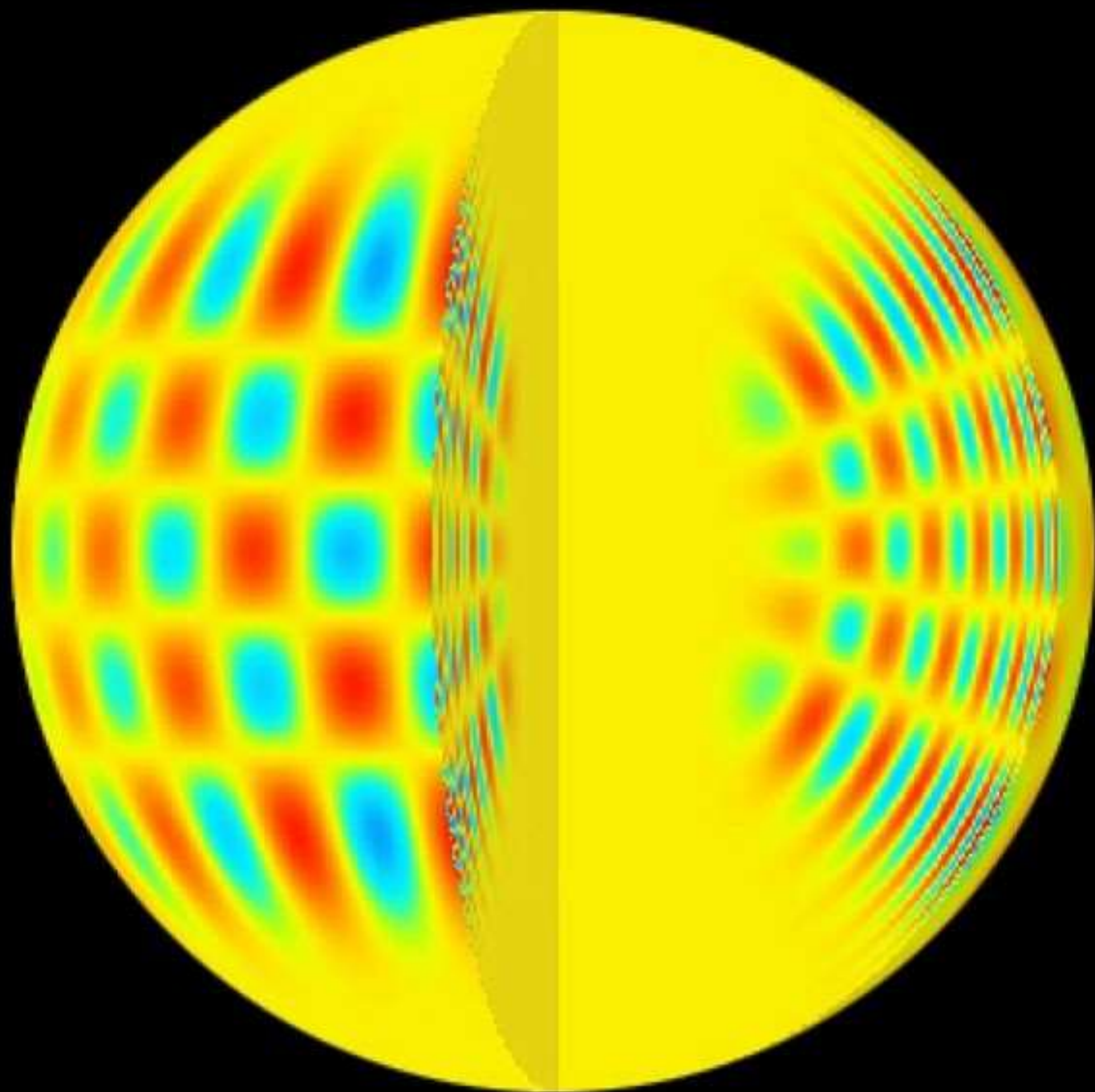


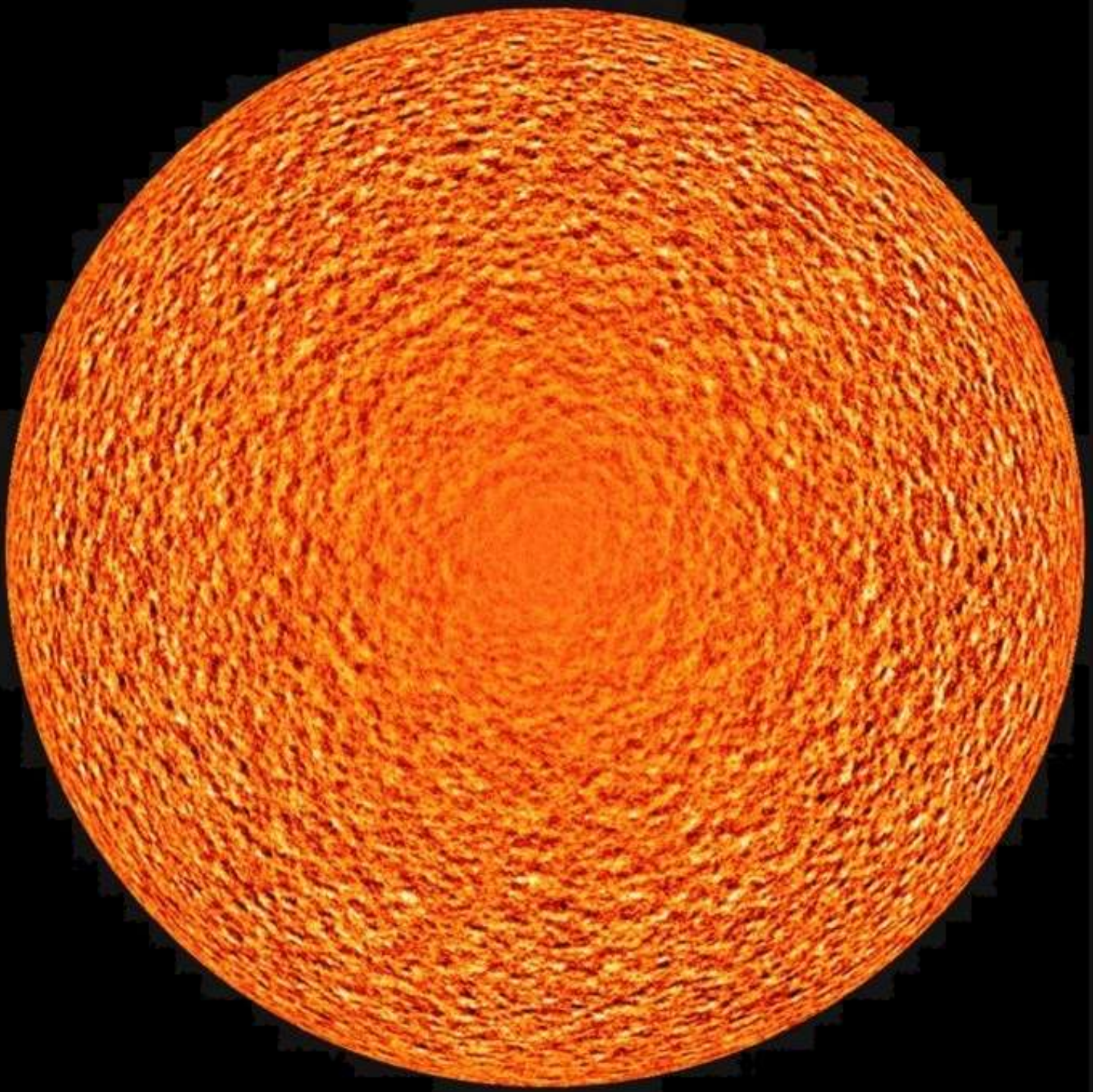
19. března 2006, blízko jižního pólu, Hinode

Zvukové vlny na Slunci

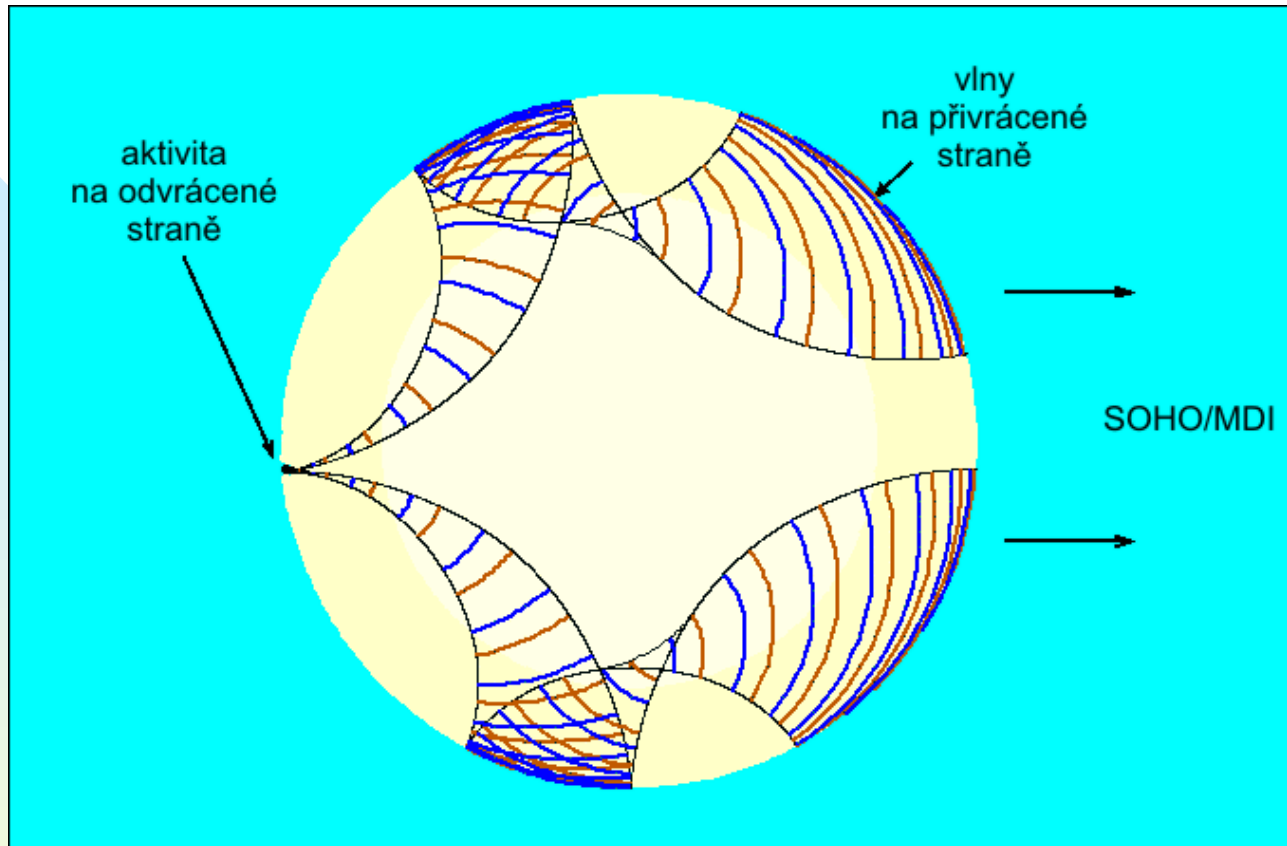


- Slunce hraje neustále
- má přes 10 milionů vlastních frekvencí
- astroseismologie, 500 nahrávek



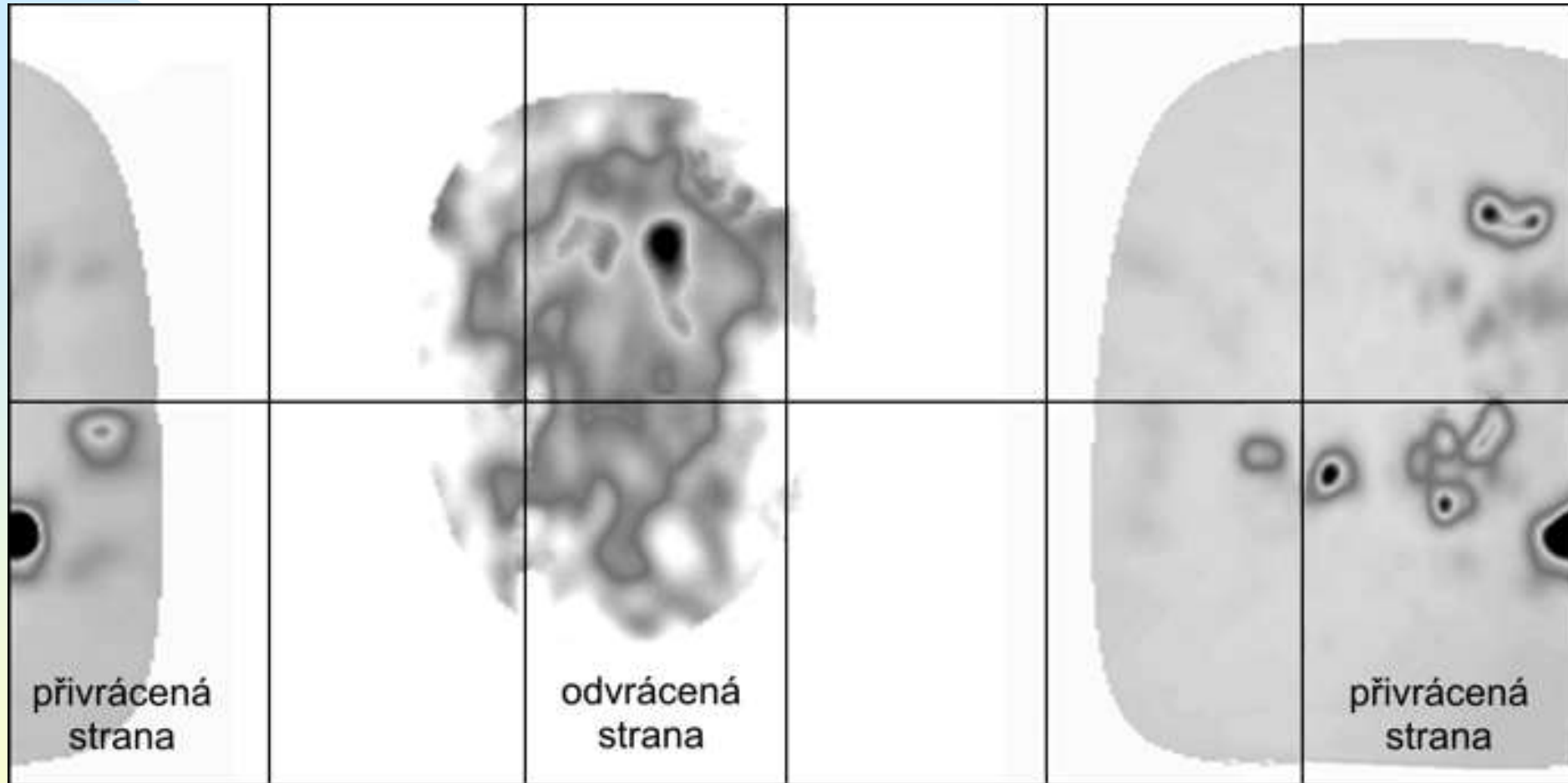


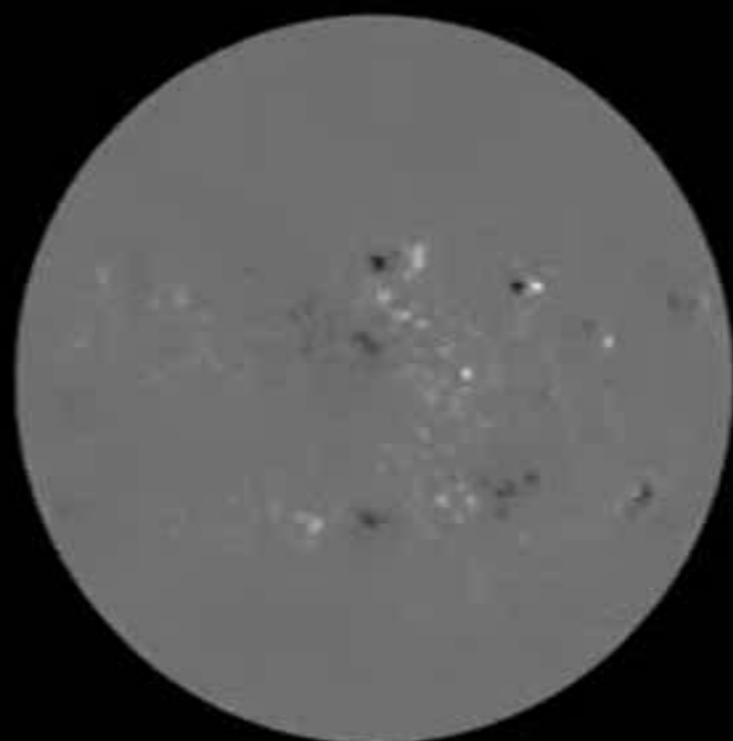
Zvukové vlny na Slunci



- **1960** Mt. Wilson 5minutové oscilace (18metrová sluneční věž)
- **1970** Roger Ulrich a d. vysvětlení
- **1980** objev podpovrchových torzních oscilací Slunce
- **1997** plazmové řeky
- **2001** rutinní obrazování odvrácené strany

Akustický hologram



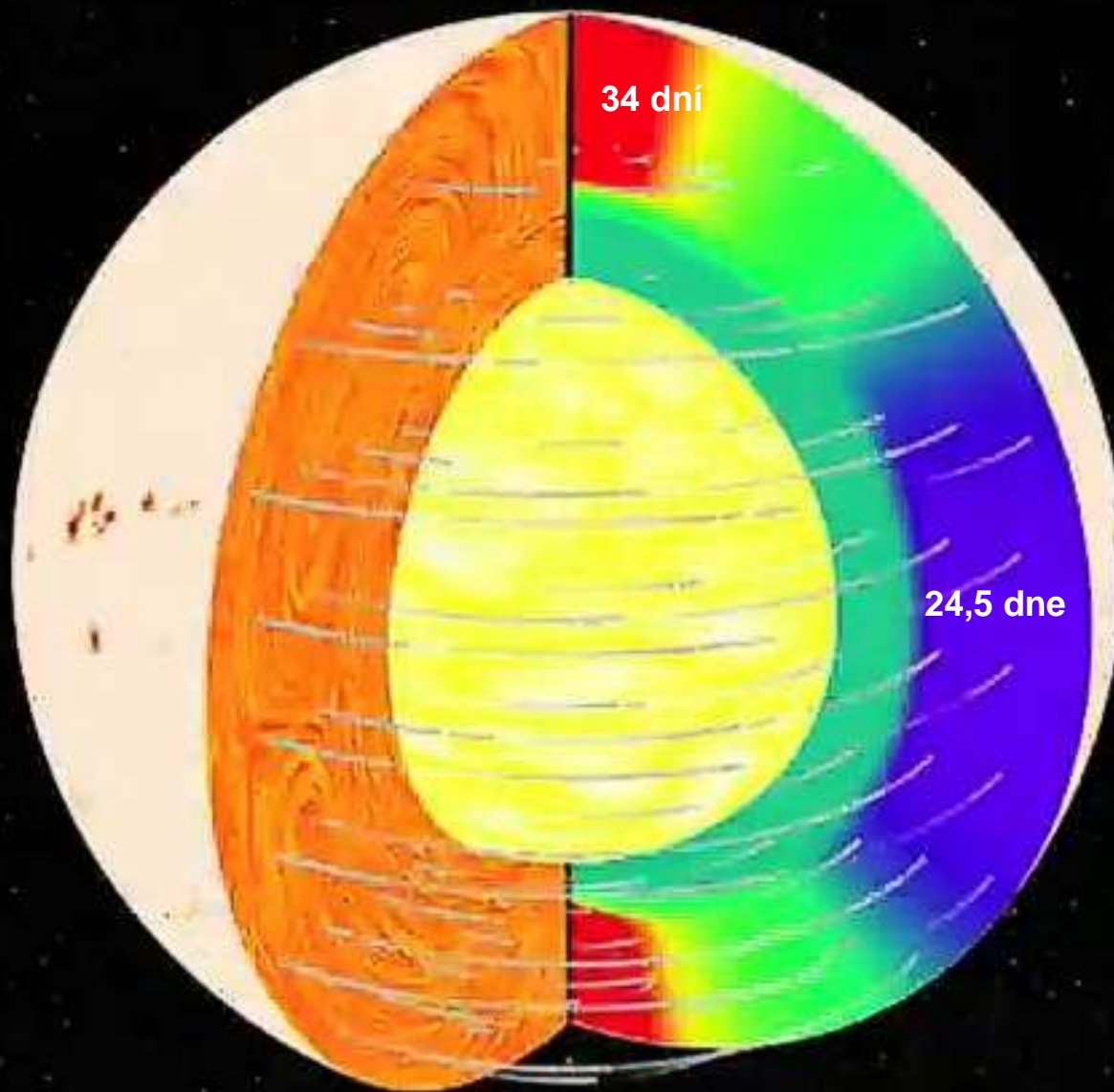


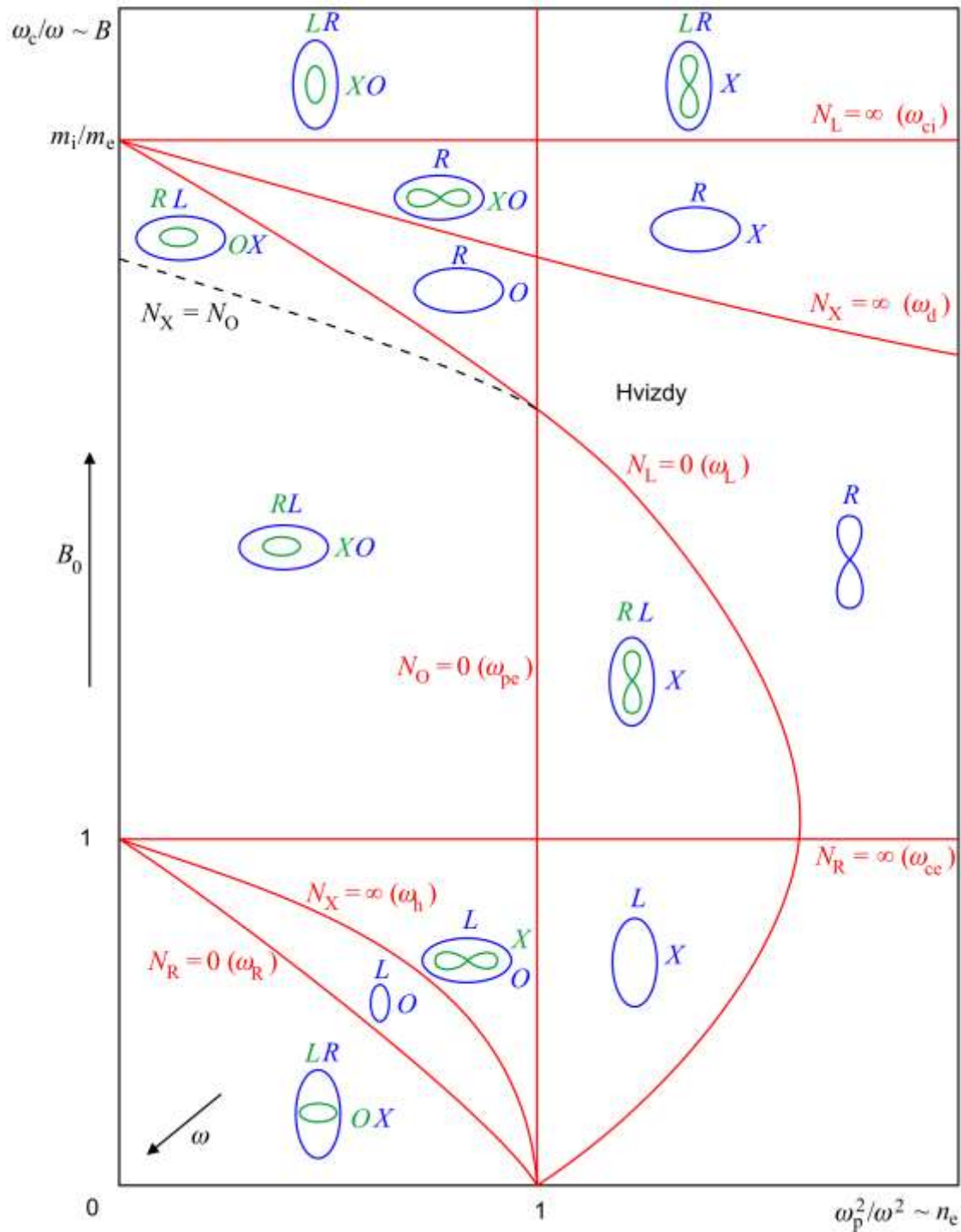
Observed
Frontside



Reconstructed
Farside

Proudění





Hvizdy, lví řevy a chóry



hvizdy 1



hvizdy 2



lví řevy



chóry

