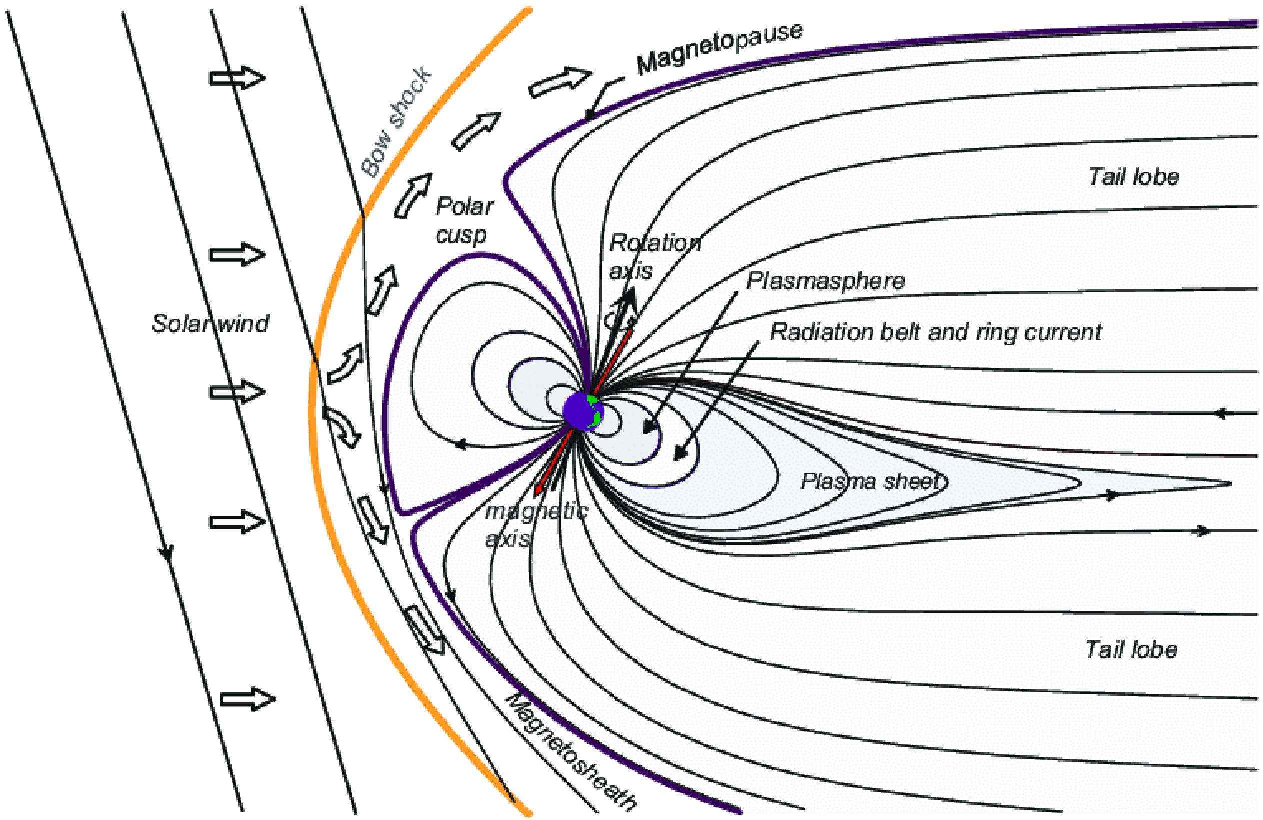
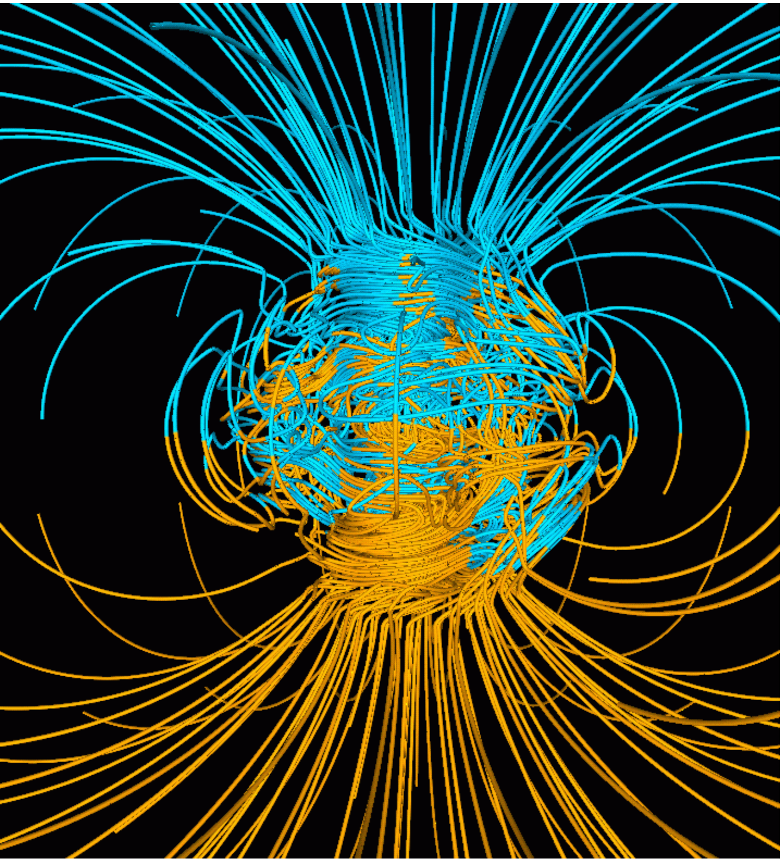
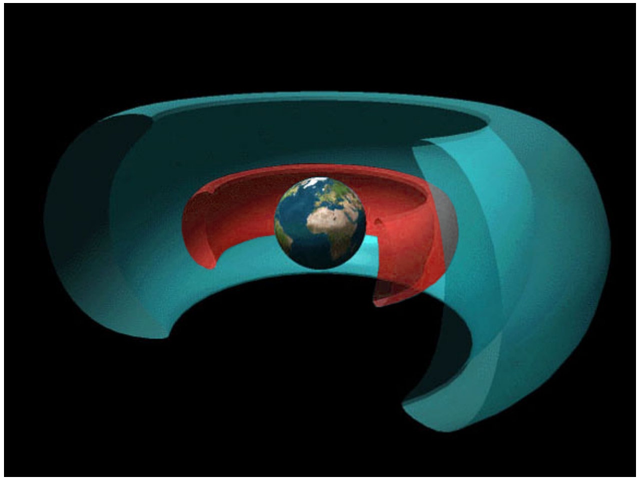
Geomagnetic field





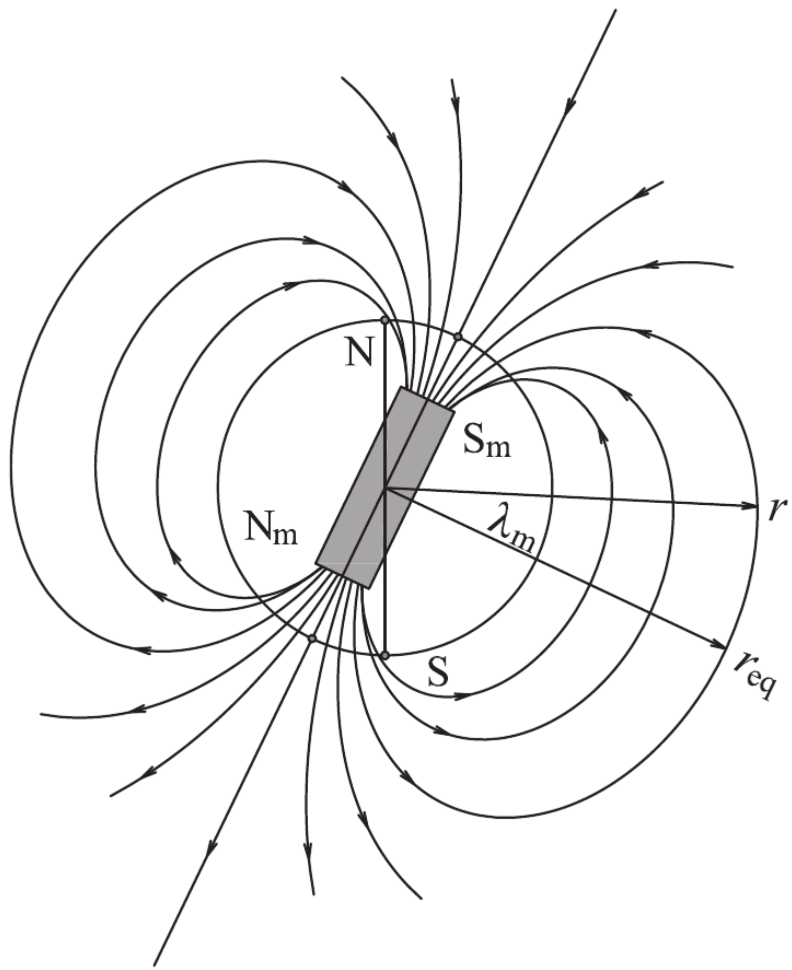


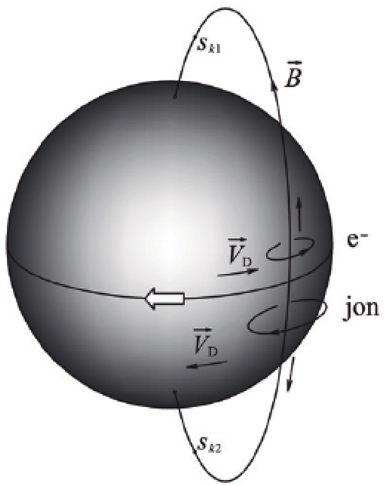
$$\vec{B} = \frac{\mu_0}{4\pi}\frac{M_\oplus}{r^3}(-2\sin\lambda_m\vec{e}_r + \cos\lambda_m\vec{e}_{\lambda_m})$$

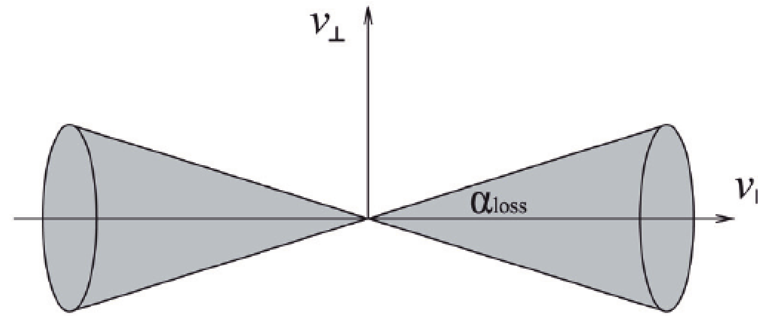
$$M_\oplus \approx 8.05 \times 10^{22} \text{ A m}^2$$

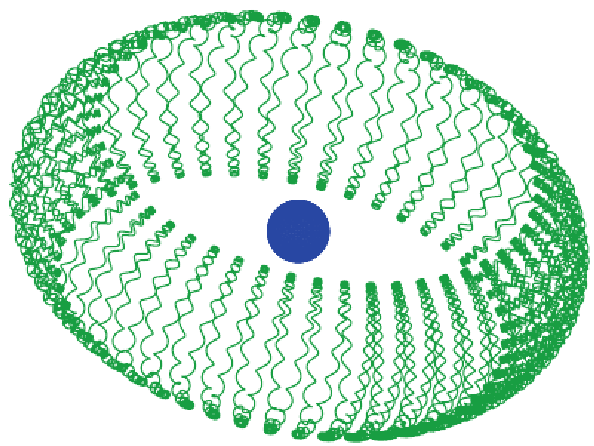
$$\mathbf{L} = r_{eq}/R_\oplus$$

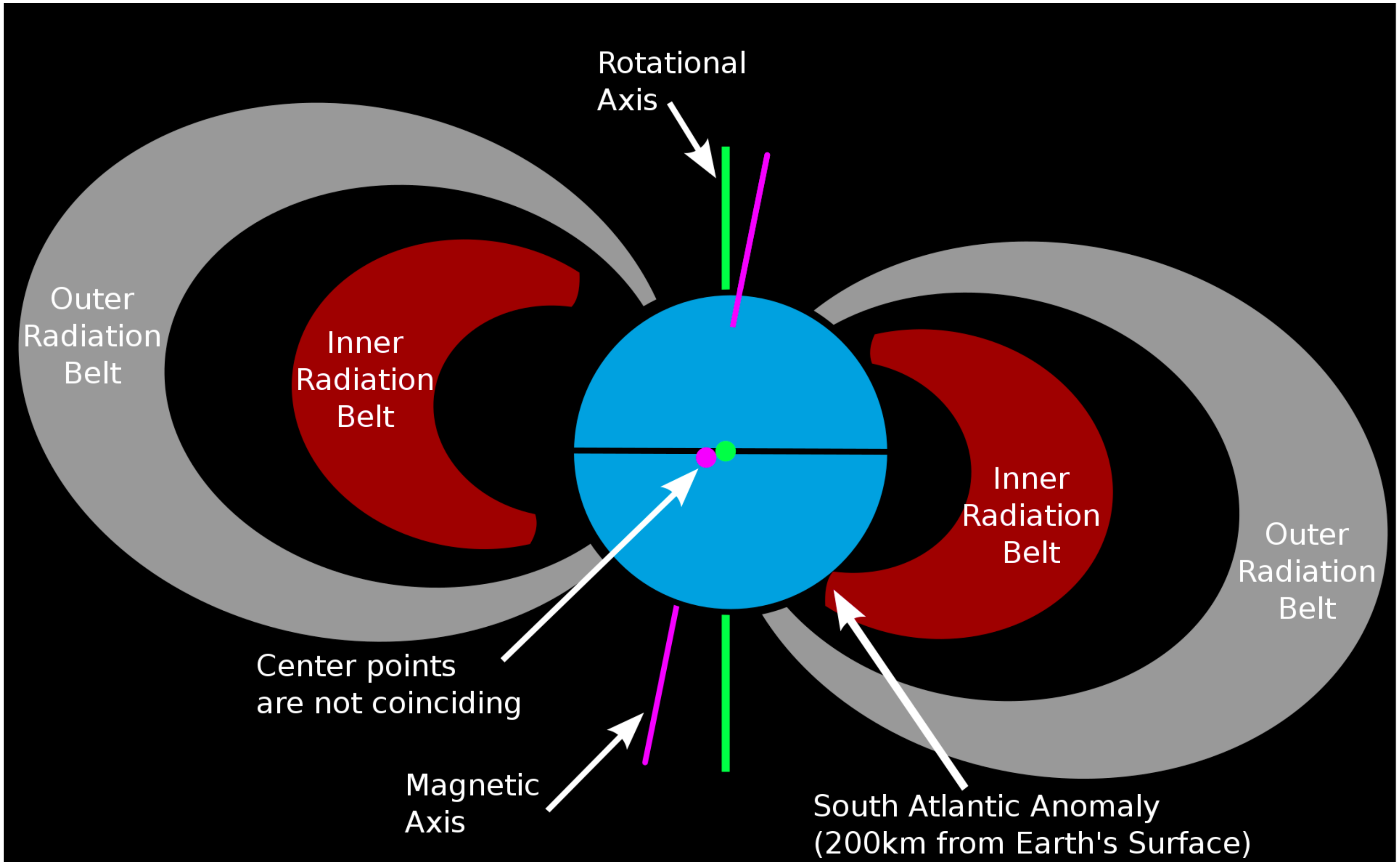
$$B(\lambda_m, \mathbf{L}) = \frac{B_\oplus}{\mathbf{L}^3}\frac{\sqrt{1 + 3\sin^2\lambda_m}}{\cos^6\lambda_m}$$

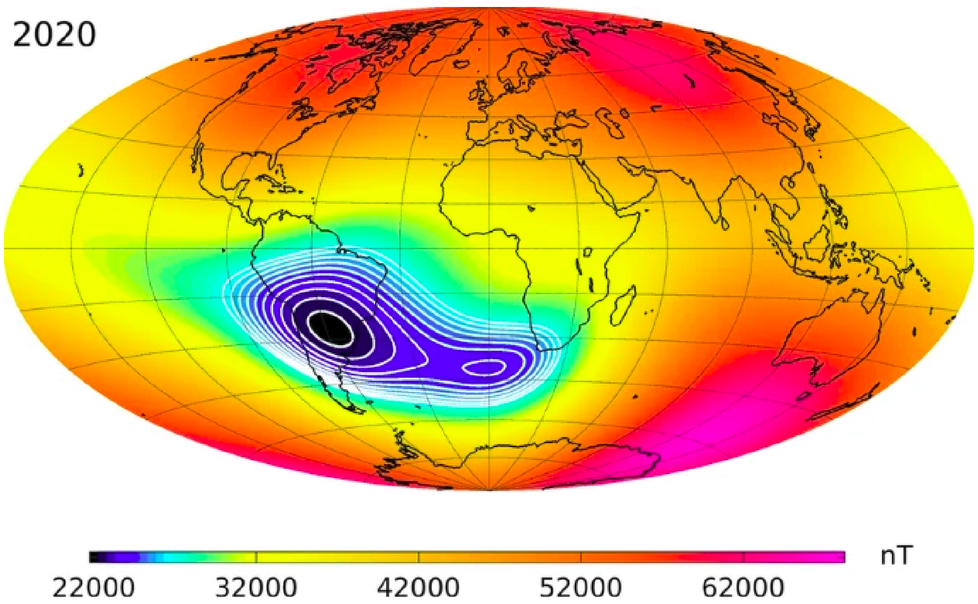



s_{k1}
$\vec{B}$
$\vec{V}_D$
e⁻
jon
$\vec{V}_D$
s_{k2}


$v_\perp$
α_{loss}
$v_\parallel$

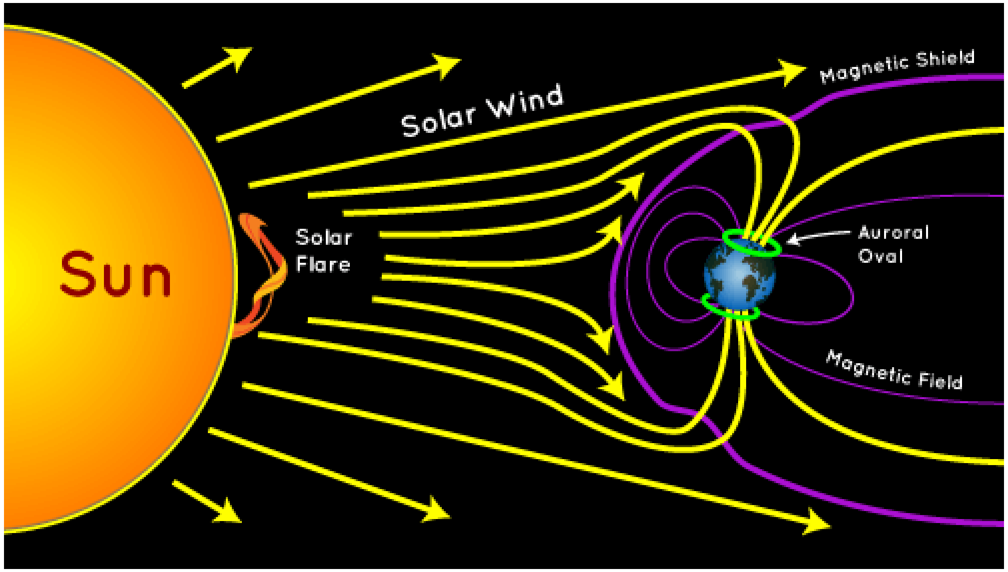



Rotational
Axis
Outer
Radiation
Belt
Inner
Radiation
Belt
Inner
Radiation
Belt
Outer
Radiation
Belt
Center points
are not coinciding
Magnetic
Axis
South Atlantic Anomaly
(200km from Earth's Surface)


2020
nT
22000
32000
42000
52000
62000

Aurora: L-values ~ 6

https://www.youtube.com/watch?v=0I1hZCD7sT0

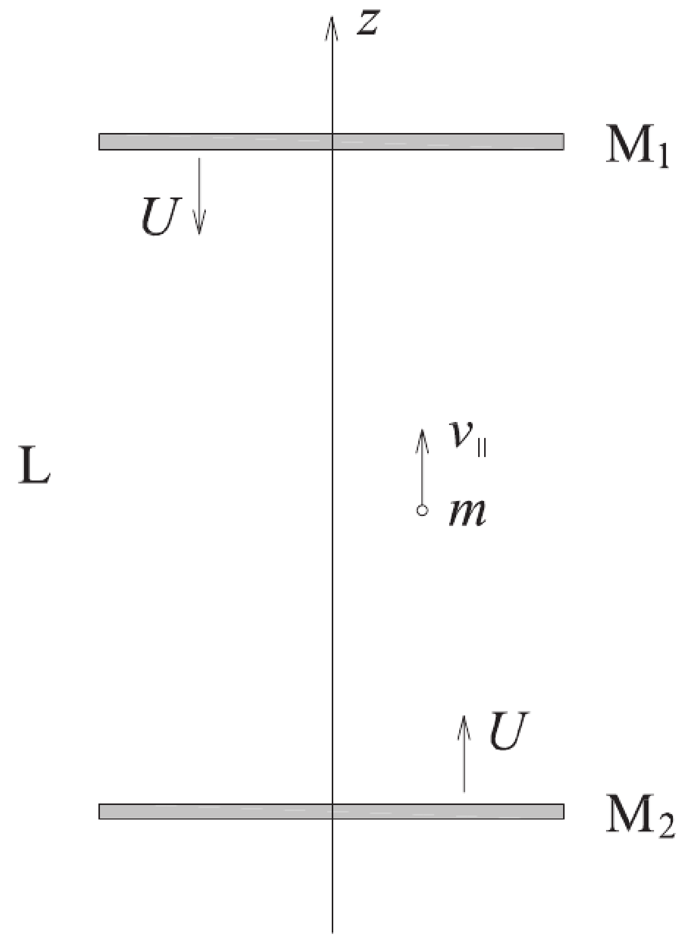


Magnetic reconnection

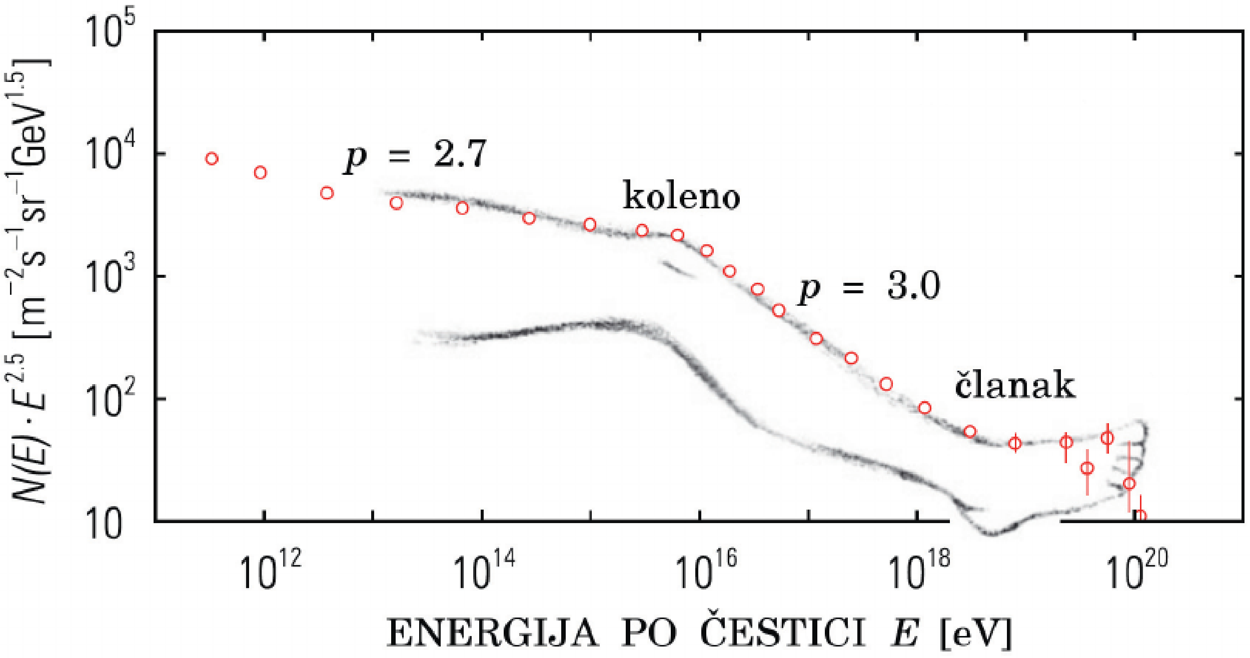
$$\oint m v_{\parallel} ds = \text{const}$$

$$p_{\parallel} \text{L} = \text{const}$$

Fermi acceleration basic



Cosmic rays



Synchrotron radiation – high energy electrons
Pion decay – high energy ions

Cosmic rays as information carriers – problems: trajectory is changed due to magnetic field...

Diffusive Shock Acceleration in quasi-parallel shocks

" Fermi first order process"

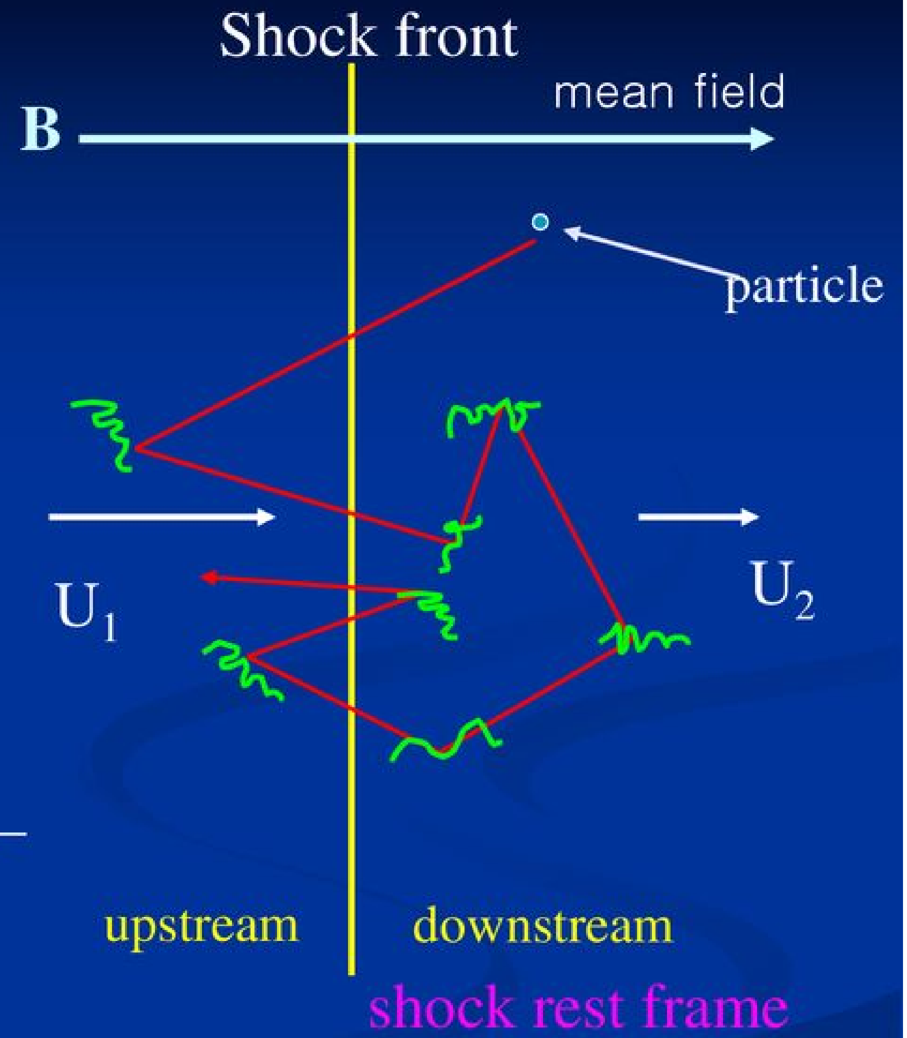
Alfven waves in a converging flow act as converging mirrors

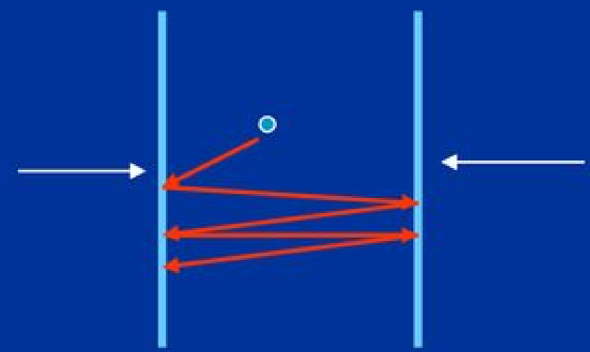
→ particles are scattered by waves

→ cross the shock many times

$$\frac{\Delta p}{p} \sim \frac{U_s}{v}$$ **energy gain at each crossing**

$$v \approx c$$





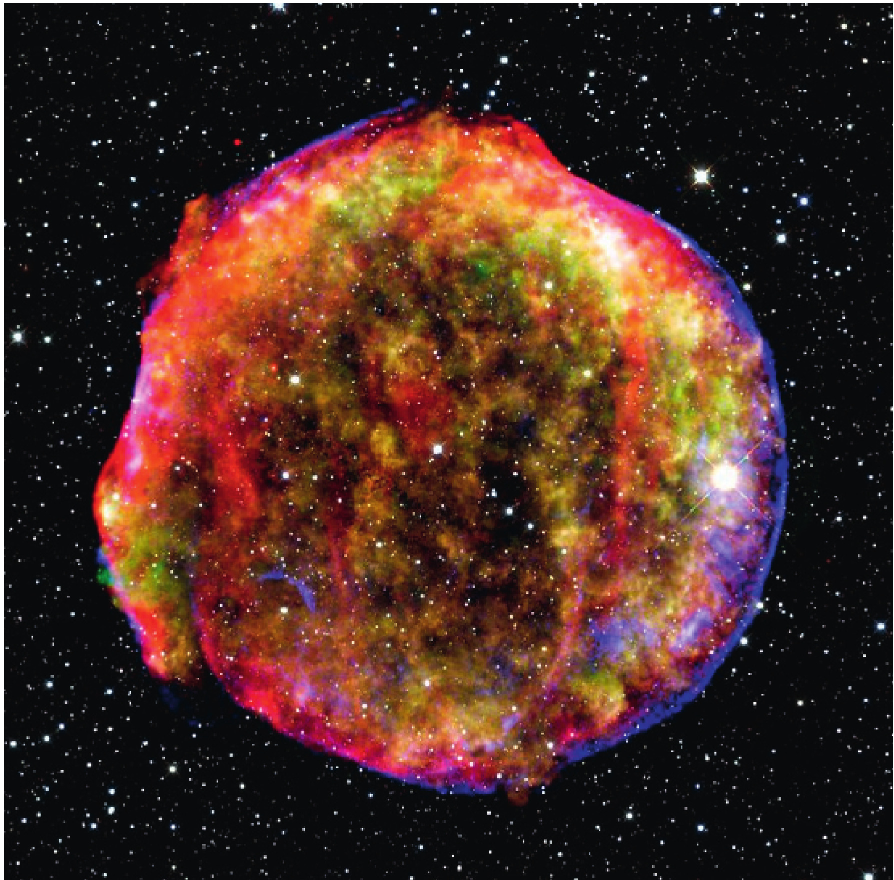
Converging mirrors

Incoherent continuum radiation can be treated in orbital method

Calculate the emissivity of one particle – find distribution of particles *N(E)* – calculate how system of particles radiate

Bremsstrahlung, synchrotron, inverse Compton, …

Thermal vs. non-thermal radiation



$$I = \frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{q^2}{c^3}\dot{v}^2$$

Cyclotron resonance

wave-particle interaction

$$\vec{B} = B\vec{\mathrm{e}}_z,\ \vec{E} = E\cos(\omega t)\vec{\mathrm{e}}_x$$

$$\ddot{x} = \omega_{\mathrm{c}}\dot{y} + \frac{q}{m}E\cos(\omega t),\ \ \ddot{y} = -\omega_{\mathrm{c}}\dot{x},\ \ \ddot{z} = 0$$

if $\omega = \omega_{\mathrm{c}}$

$$r_{\mathrm{c}} \equiv v_{\perp}^{0}/\omega_{\mathrm{c}}$$

$$x = r_{\mathrm{c}}\big(1 - \cos(\omega_{\mathrm{c}}t)\big) + \frac{q}{m}\frac{Et\sin(\omega_{\mathrm{c}}t)}{2\omega_{\mathrm{c}}},$$

$$y = r_{\mathrm{c}}\sin(\omega_{\mathrm{c}}t) + \frac{q}{m}\frac{E}{2\omega_{\mathrm{c}}^2}\big(\omega_{\mathrm{c}}t\cos(\omega_{\mathrm{c}}t) - \sin(\omega_{\mathrm{c}}t)\big)$$