

Magnetized, non-atmospheric body.

Surface magnetic field $\sim 200 \text{ nT}$

(Mariner 10, Messenger)

cf. 30000 nT at Earth surface

Magnetopause distance

$$\frac{1}{2} \rho v^2 = \frac{B^2}{2\mu_0} \quad (\text{pressure balance})$$

$$B \propto \frac{1}{r^3} \quad (\text{dipole field})$$

$$B_0 = 200 \text{ (nT) (surface)}$$

$$\rho = m_p \times 20 \text{ (cm}^{-3}\text{)} \quad (\text{solar wind mass density})$$

$$v = 300 \text{ (km/s)} \quad (\text{solar wind speed})$$

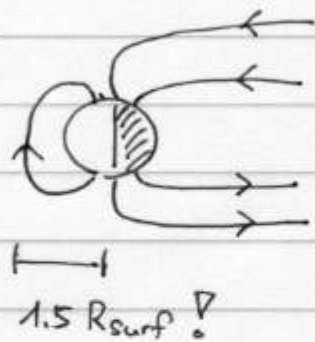
$$\rightarrow R_{mp} \approx 1.5 R_{surf} \quad !$$

(from planet center)

surface - magnetopause distance

$$0.5 R_{surf} = 1200 \text{ km}$$

Magnetosphere



weak magnetic field



small magnetosphere

- No radiation belt (or ring current)
 - ... planet ^{occupies} ~~is occupying~~ a lot of volume
- Sodium (Na) sputtering
 - sodium-rich plasma
- "Hybrid" scale ... magnetosphere size of the order of ion gyro-radius
 - currents are carried by electrons? (mpause, plasma sheet)
- **Fast reaction, rapid reconfiguration**

length dayside-tail $l \sim 10 R_{\text{surf}}$ (24000 km)

solar wind speed $v \sim 300 \text{ km/s}$

↘

reaction time $\tau = l/v \sim 80 \text{ s}$

(cf. 40 min. at Earth)

- reconnection? substorm?

Dynamo problem

Theoretical estimate of surface magnetic field

$$\Lambda = \frac{\text{Lorentz force}}{\text{Coriolis force}}$$

$$= \frac{|\sigma(\vec{v} \times \vec{B}) \times \vec{B}|}{|2\rho\vec{\Omega} \times \vec{v}|}$$

$$\sim \frac{\sigma B^2}{2\rho\Omega}$$

Assume $\Lambda \sim 1 \Rightarrow B \propto \sqrt{\Omega}$.

Scale Earth magnetic field into Mercury,

$$B(\text{earth}) = 30000 \text{ nT}$$

$$\Omega(\text{earth}) = \frac{2\pi}{1} \text{ (rad/day)}$$

$$\Omega(\text{merc}) = \frac{2\pi}{58} \text{ (rad/day)}$$

$$\Rightarrow B(\text{merc}) = 4000 \text{ nT.}$$

Mercury field is weaker than Earth-scaled field.

Lost dynamo

Venus and Mars have atmosphere
but no global magnetic field.
(dipole)

Estimate of dipole moment (upper limit!)

Venus $10^5 \times$ (Earth dipole)
 \rightarrow 0.1 nT at surface pvo

Mars $10^{25} \times$ (Earth dipole)
 \rightarrow ~~100~~ 0.5 nT at surface MGS

Mars have magnetized crust
e.g. 200 nT at 400 km altitude

\rightarrow Dynamo operating in early time?

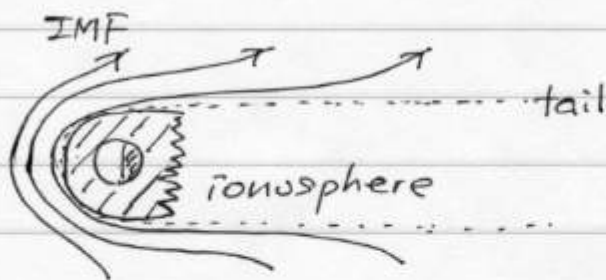
Why is dynamo missing?

Venus ... slow rotation (243 days)?

Mars ... core in solid state?

(Liquid core became solid,
Small planet size)

Magnetosphere



Pressure balance

(1) magnetic boundary

$$\frac{1}{2} \rho v^2 = \frac{B^2}{2\mu_0}$$

solar wind
dynamic
pressure

solar wind
magnetic pressure

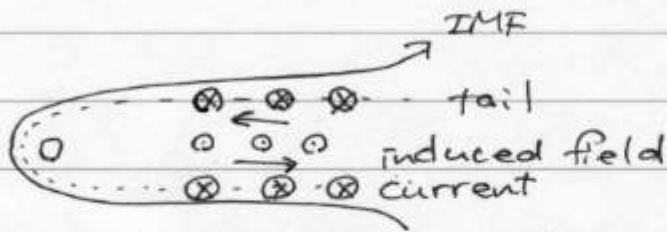
↕
field compression
on dayside

(2) ionopause

$$\frac{1}{2} \rho v^2 = nkT$$

ionosphere
gas pressure

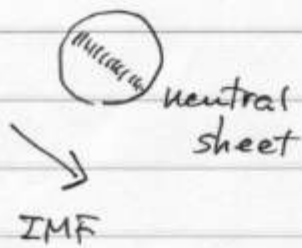
Induced magnetic field



↳ "induced magnetosphere"

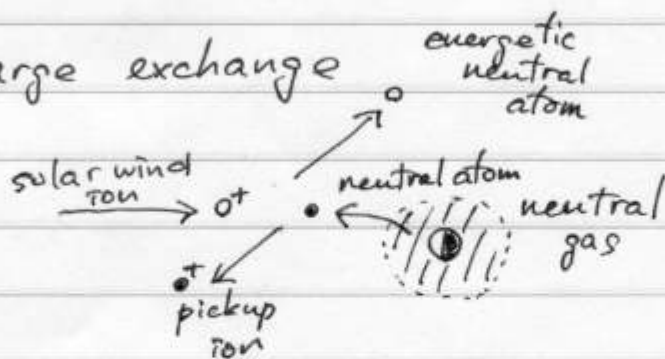
sensitive to IMF direction

tail cross section

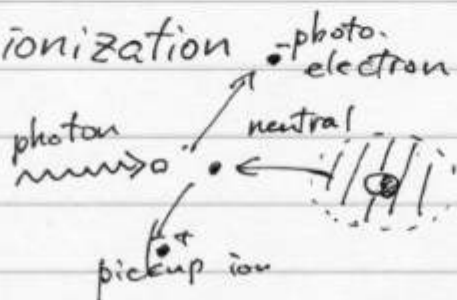


Pickup process

(1) charge exchange



(2) photoionization



plasma gains additional mass

