Modélisation du vent solaire en préparation à Solar Orbiter

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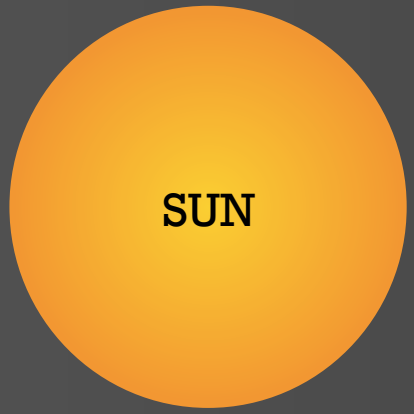
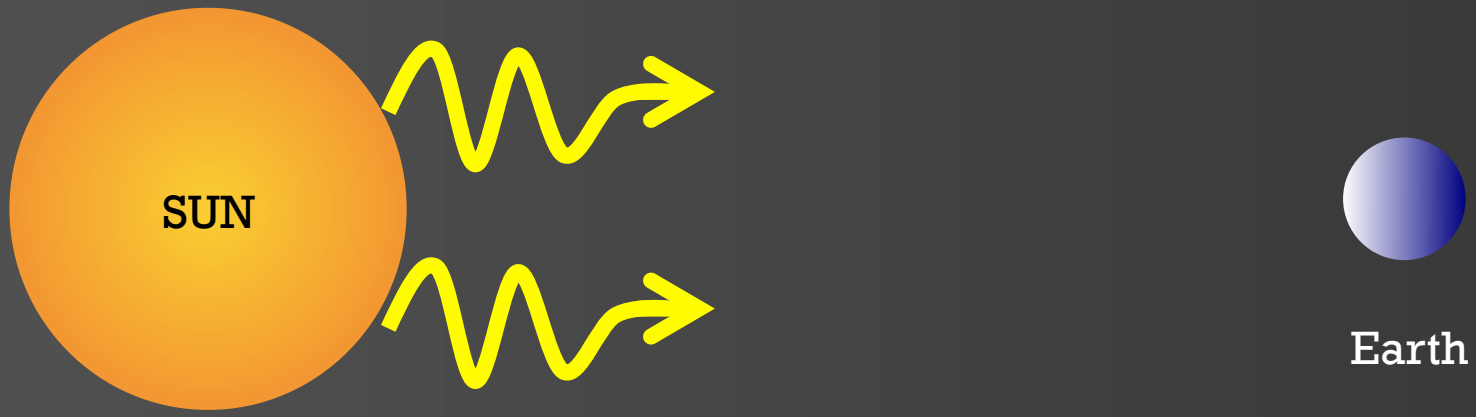
What is solar wind

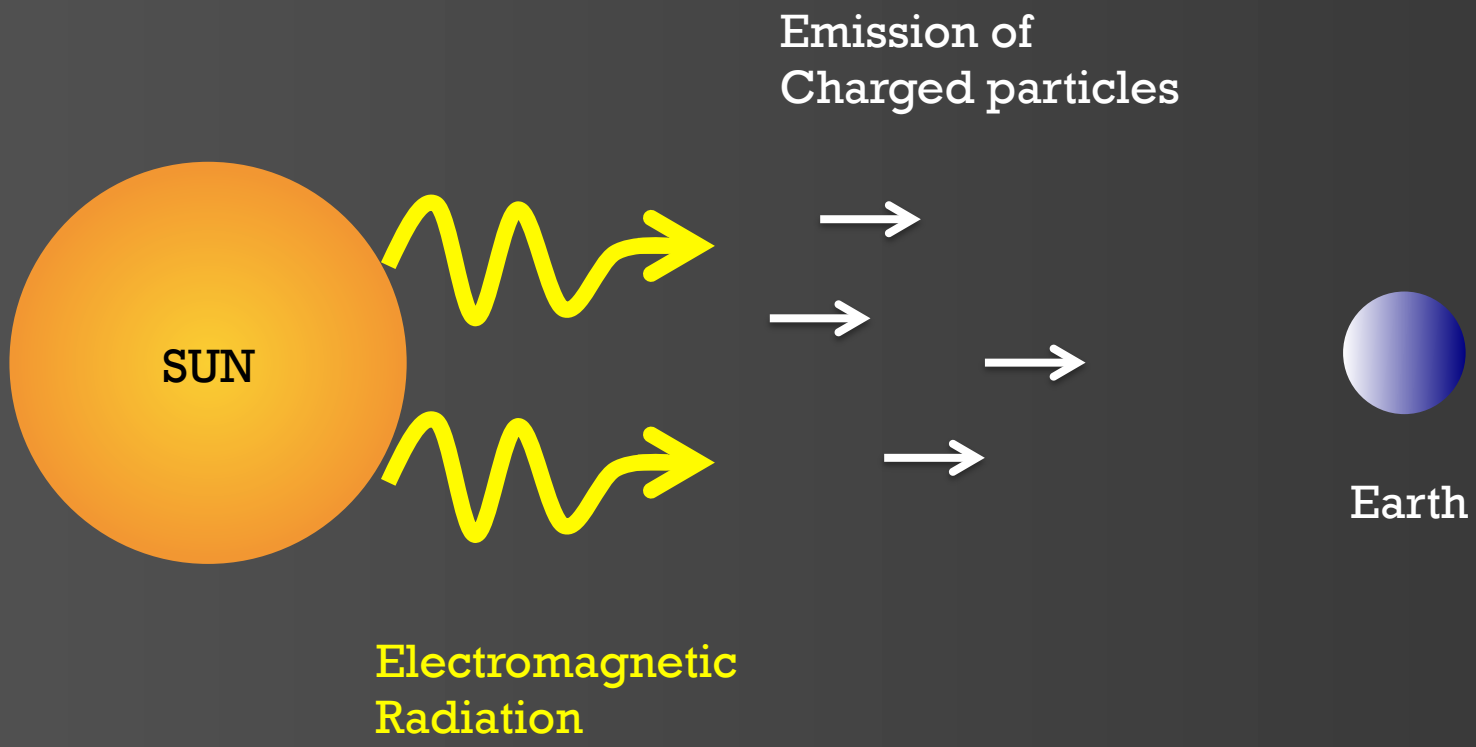


Earth

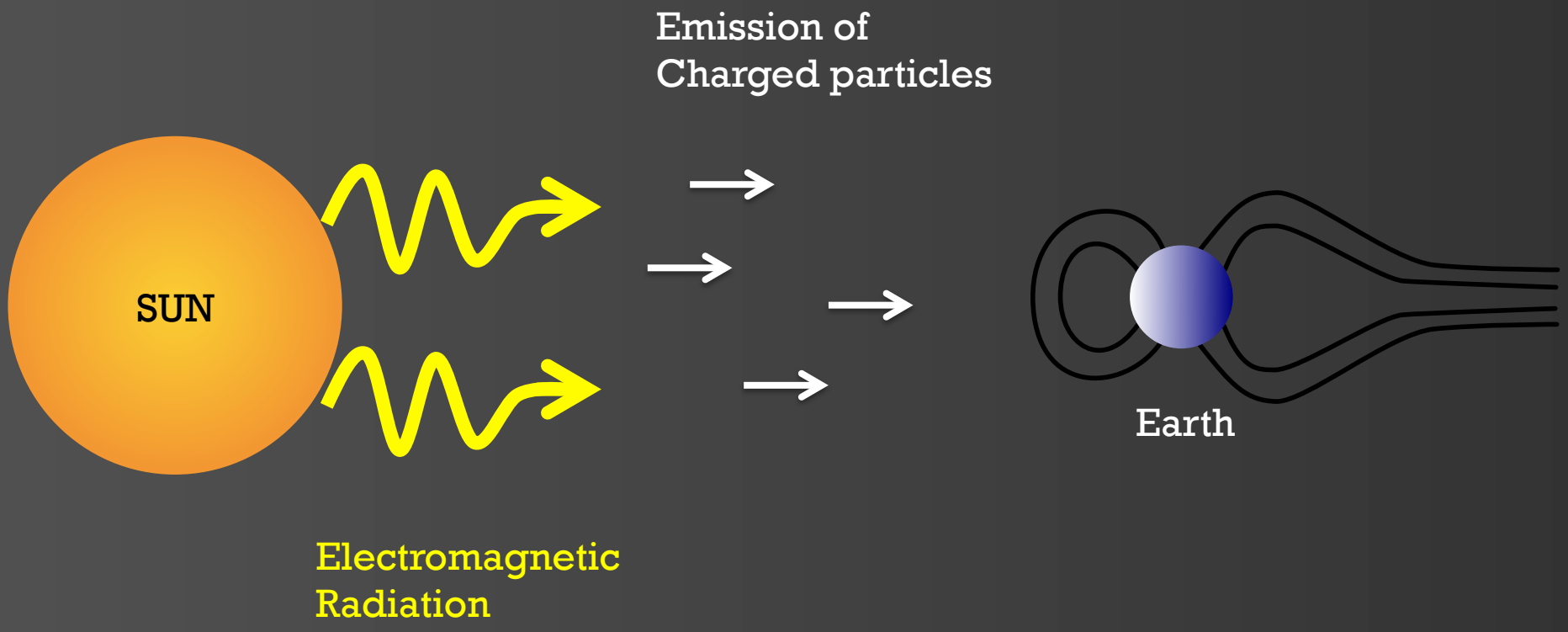
What is solar wind



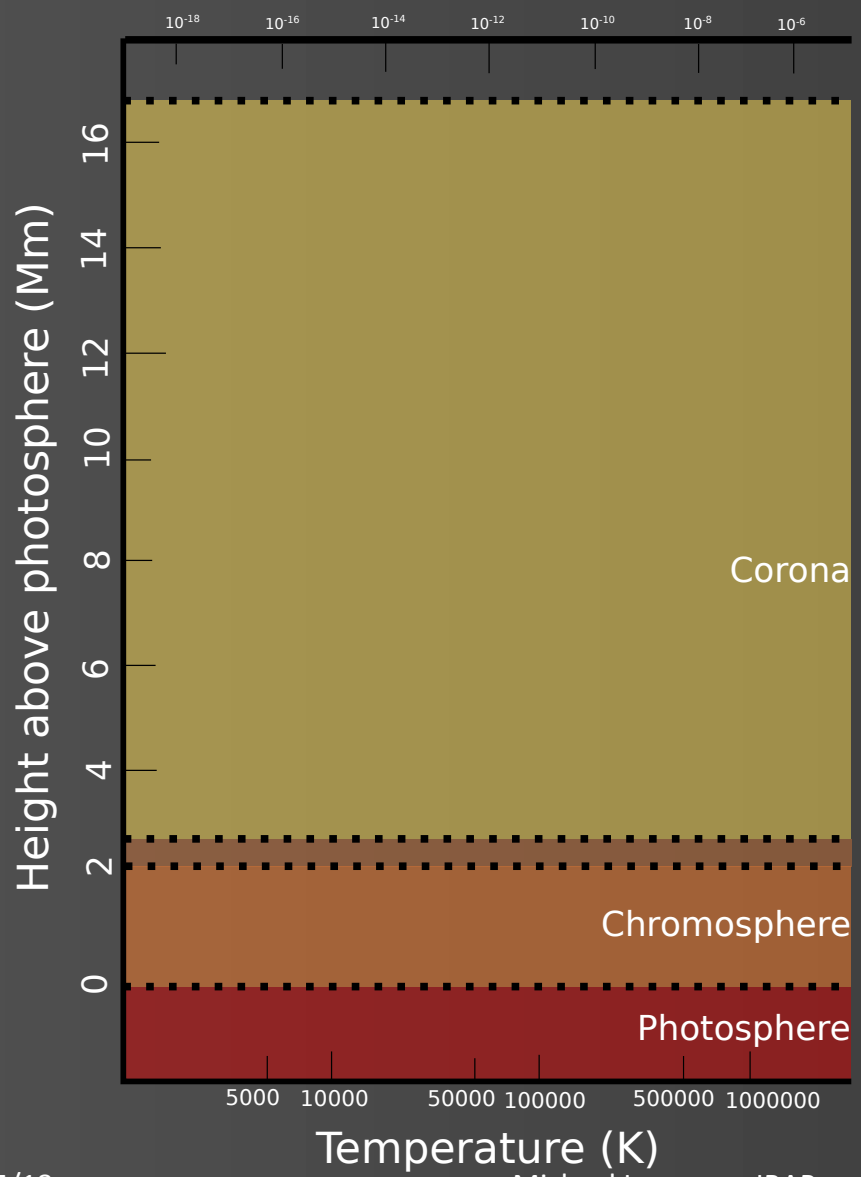
What is solar wind



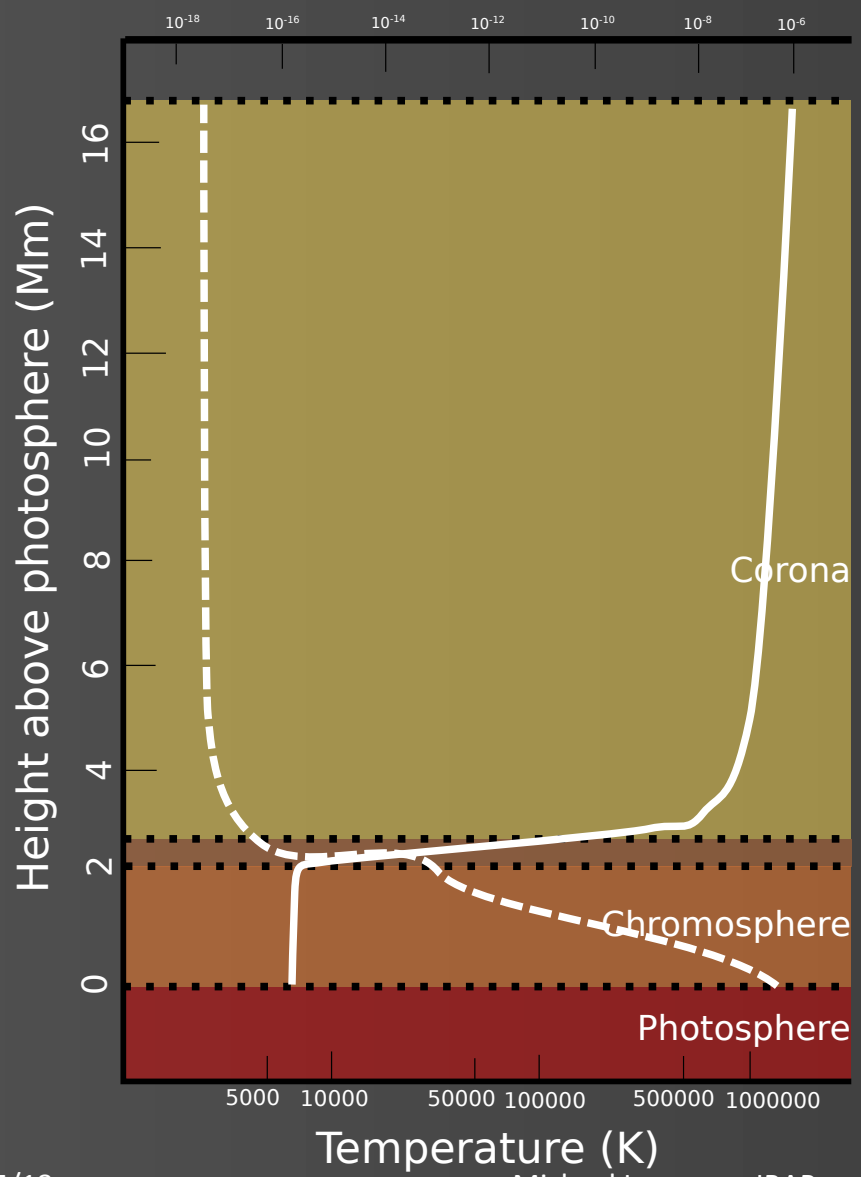
What is solar wind



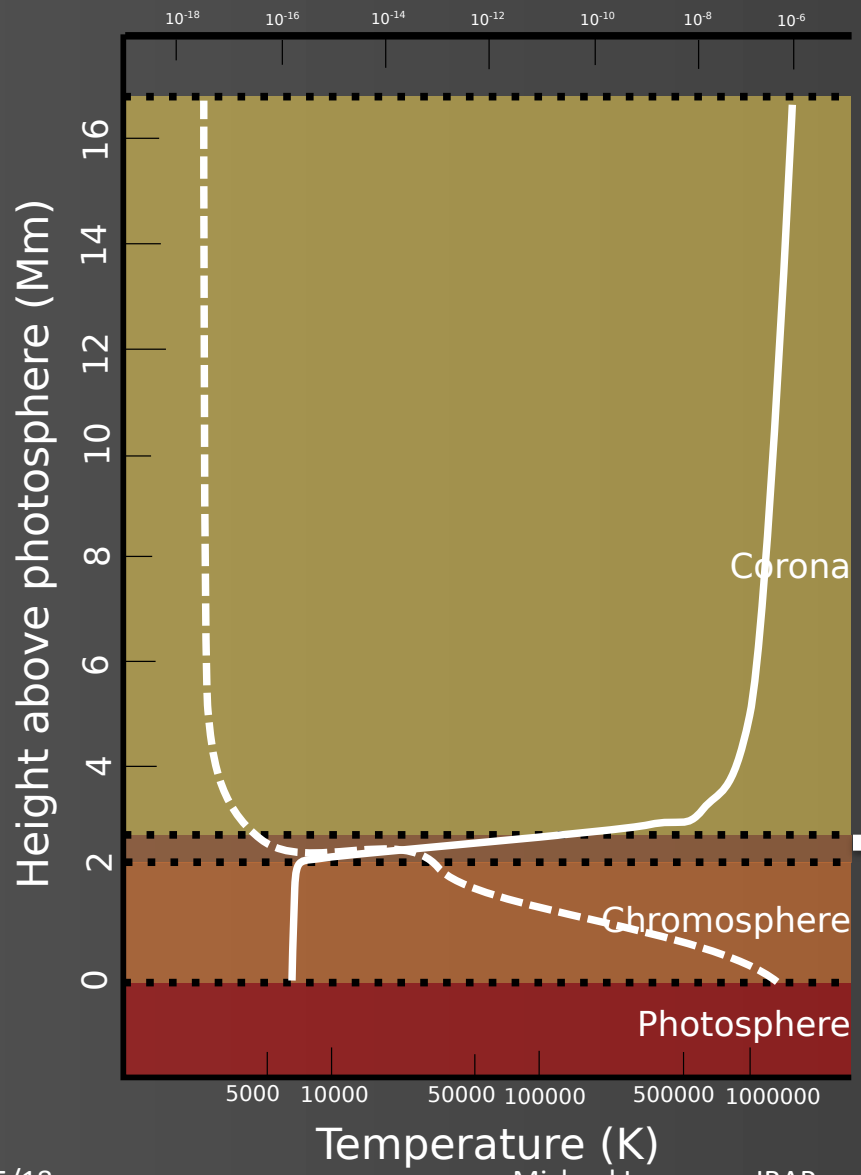
What causes solar winds



What causes solar winds



What causes solar winds



Fully ionised

Hot

Magnetic forces

Partially ionised

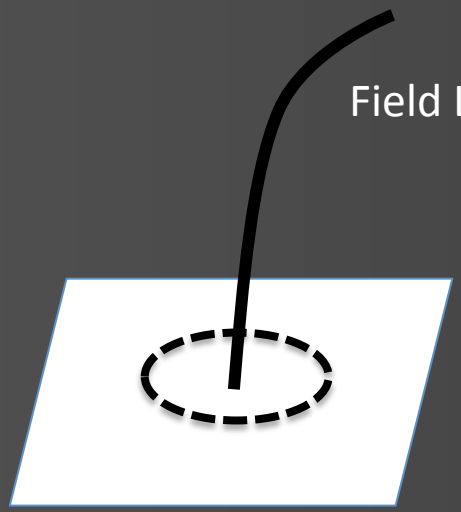
Cold

Collision

Solar Wind Model

- Very collisional to Not collisional
- Important Magnetic Field

Creates Anisotropies
// and ⊥ to magnetic field



Solar Wind Model

- Very collisional to Not collisional
- Important Magnetic Field

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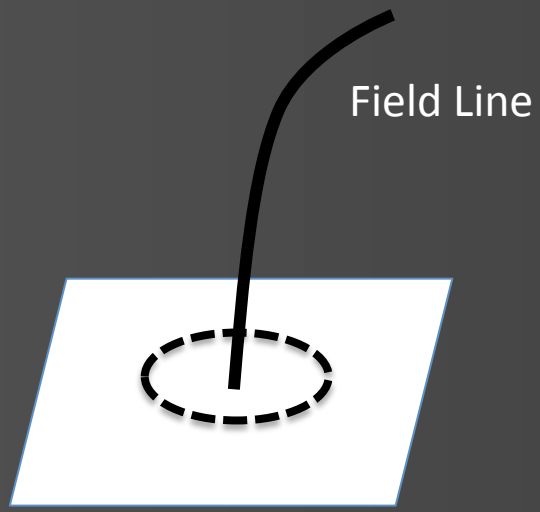


In the collisionless layers, the emerging anisotropies can't be cancelled.

The Model have to deal with :
- Anisotropies
- Multiple species (H, protons, electrons, He …)
- Rapid changes in density and temperature

Solar Wind Model

Boltzmann equation

Fluid

Maxwellian distribution fonction

Solar Wind Model

Fluid

Boltzmann equation

↓ Maxwellian distribution fonction

Continuity (Density ρ)
Momentum (Drift velocity V)
Energy (Temperature T)

Unknowns : ρ , V, T, Q

We need to add a other equation to close the system.

Fourier's Law : $Q = -\lambda \nabla T$
(Heat goes from high T to low T)

Solar Wind Model

Boltzmann equation

Gyrotropic Model

↓

Bi-Maxwellian distribution fonction

Continuity (Density ρ)
Momentum (Drift velocity V)
Energy (Temperature T // and $\perp$)
Heat flow (Heat flow Q // and $\perp$)

Unknowns : ρ , V, T// , T$\perp$, Q// , Q$\perp$

We solve these transport equation for all of the considered species (H, protons, electrons)

~~Fourier's Law : $Q = -\lambda \nabla T$~~

+ We add sources from collision, chemistry, ionisation, …

Solar Wind Model

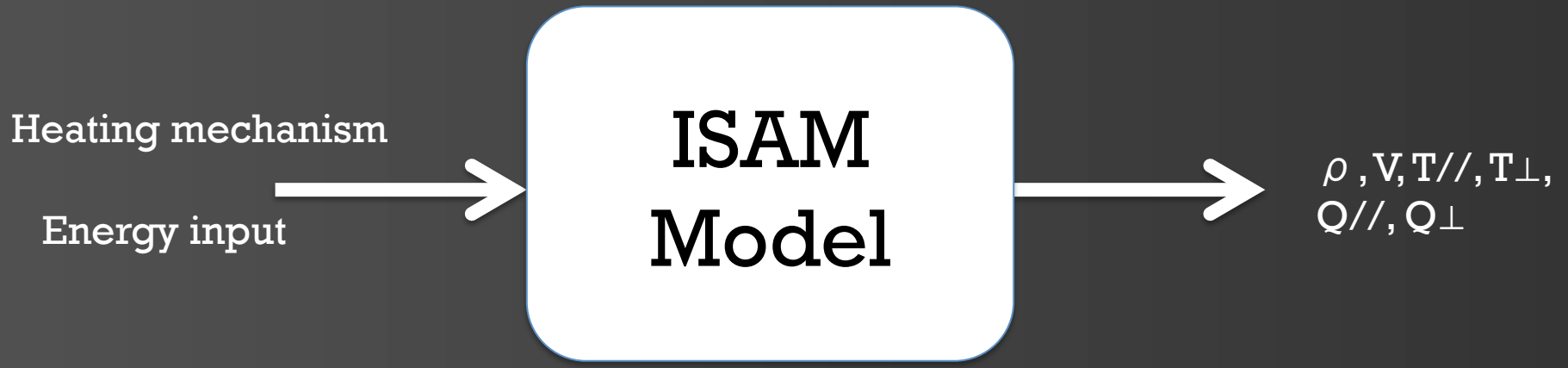
With this model we are able to :

- Handle the transition between high and low density

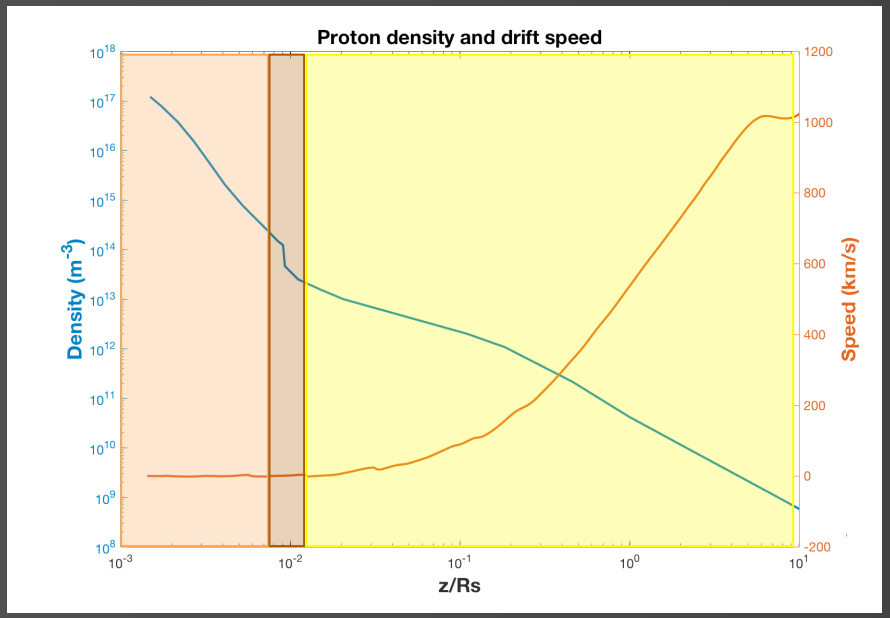
Chromosphere => Corona => Earth

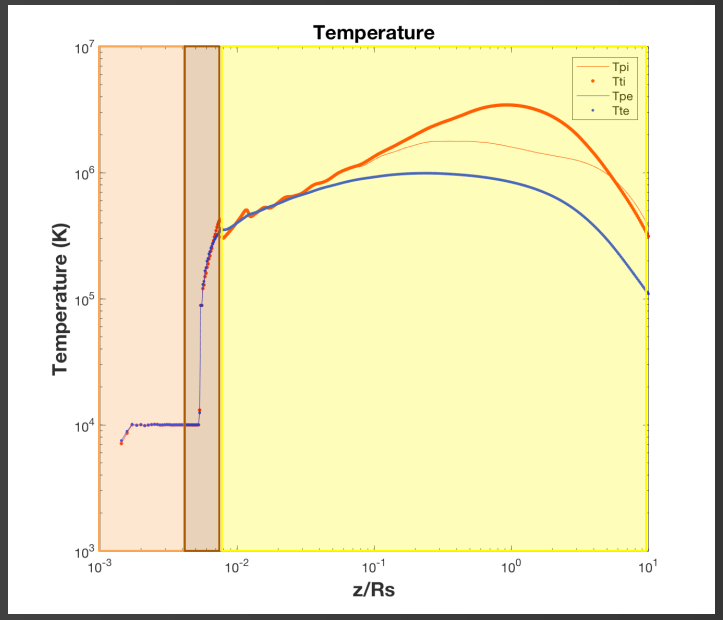
- Compute the anisotropies due to the magnetic Field

- Solve directly the heat flow



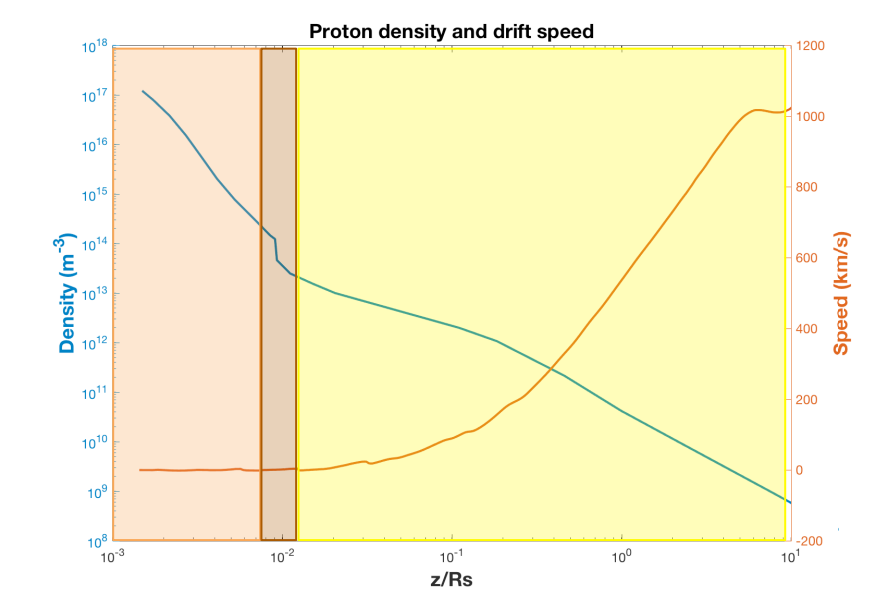
Results





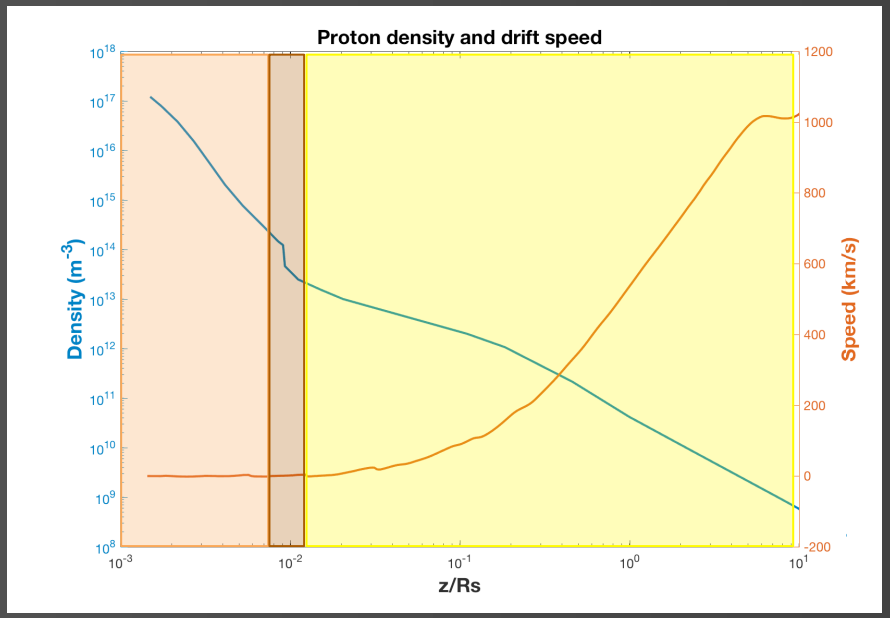
We get a supersonic wind. By extending to 215 Rsun we will be able to compare with data from spacecratf missions (Stereo, Wind, Helios, Messenger)

Results



InSitu

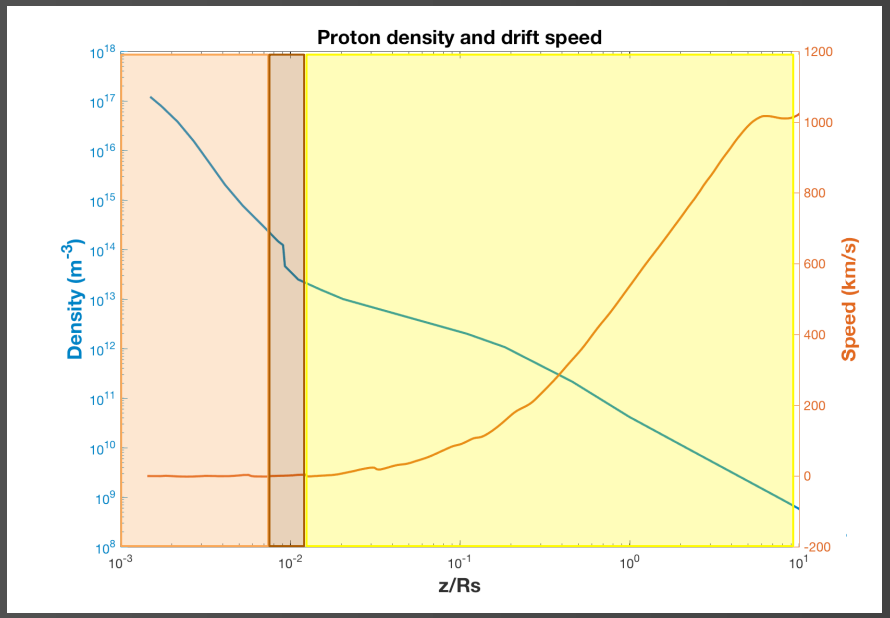
Results



Helios

InSitu

Results



Helios

InSitu

Solar Orbiter will get as close as 45 Rsun provinding the closest view of the sun

Thank you for your attention.

Any Question ?