INTERPLANETARY EFFECTS ON PLANETARY ENVIRONMENTS: VENUS AND MERCURY

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PS1.4 Planetary Space Weather

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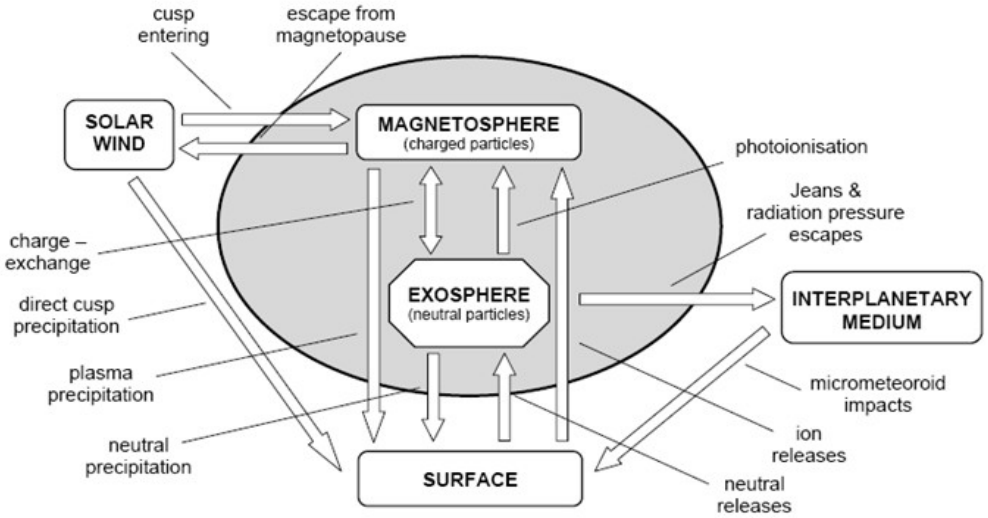
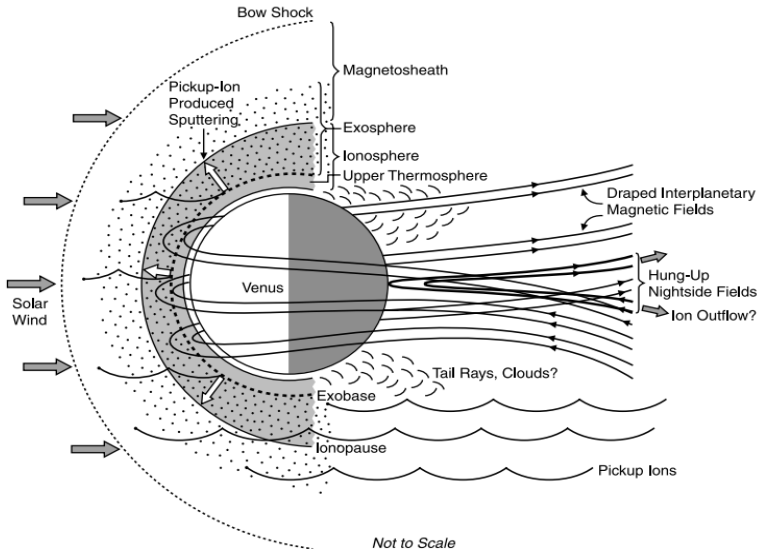
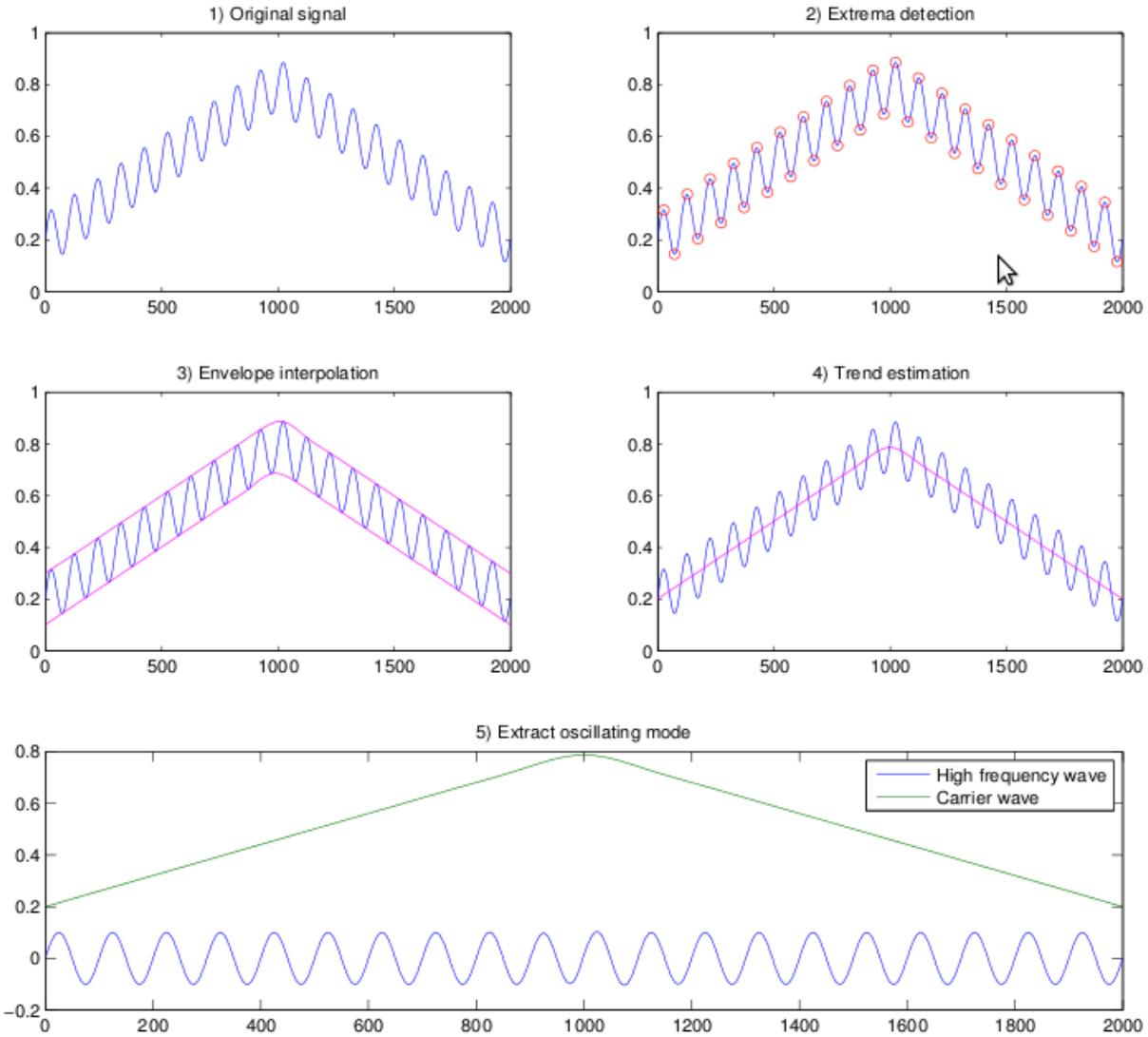
- the interplanetary medium and planetary environments are multiscale complex systems characterized by several types of processes
- the Hermean environment is characterized by an internal magnetic field generated from the core closely interacting with the ambient solar wind
- interplanetary medium variability affects charged and neutral particle precipitation mechanisms, ion and neutral releases for the surface, photoionisation phenomena
- the Venus' environment is characterized by an induced nature of its magnetosphere
- the interaction with the ambient solar wind produces a magnetosphere, a magnetosheath, and several mechanisms as sputtering, wave-particle interactions and so on





Empirical Mode Decomposition (EMD)

- a signal $X(t)$ is decomposed into a set of empirical modes $C_k(t)$ and a residue $R(t)$



$$X(t) = \sum_{k=1}^{N} C_k(t) + R(t)$$

$$C_k(t) = A_k(t)\cos\left[\Phi_k(t)\right]$$

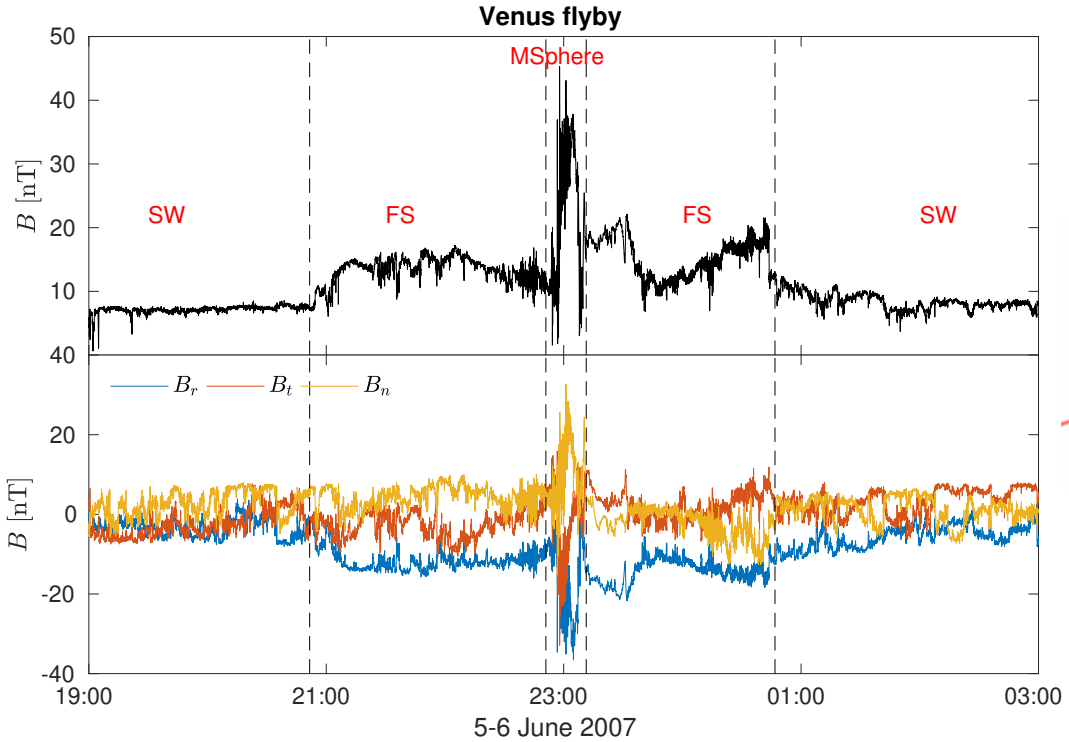
$$f_k = \frac{1}{2\pi}\frac{d\Phi_k(t)}{dt}$$

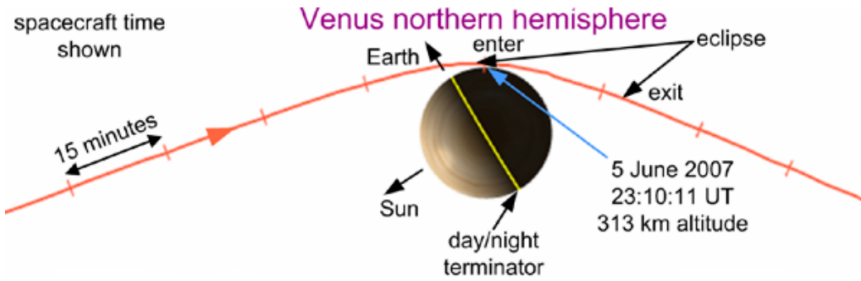
$$\mathcal{H}(f) = \frac{\mathbb{E}\left[C_k^2(t)\right] - \mathbb{E}\left[C_k(t)\right]^2}{f_k}$$

$$X_{f_1,f_2}(t) = \sum_{k' : f_{k'} \in [f_1, f_2]} C_{k'}(t)$$

VENUS FLYBY

- MESSENGER → June 5th, 2007: crossing FS and MSphere

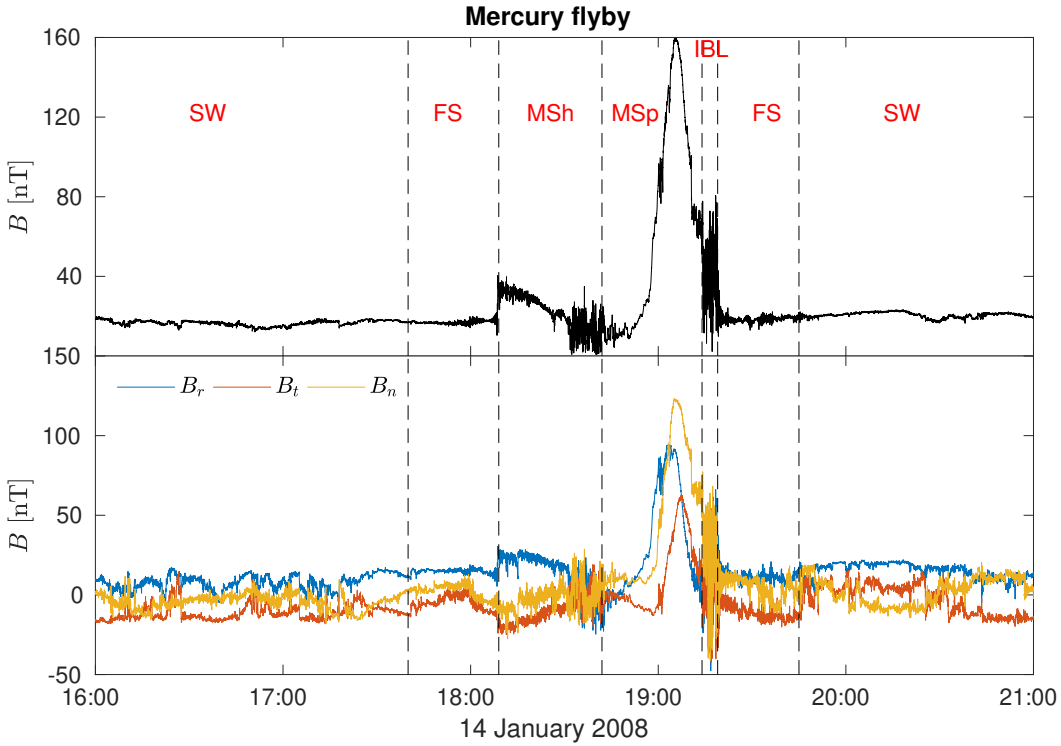


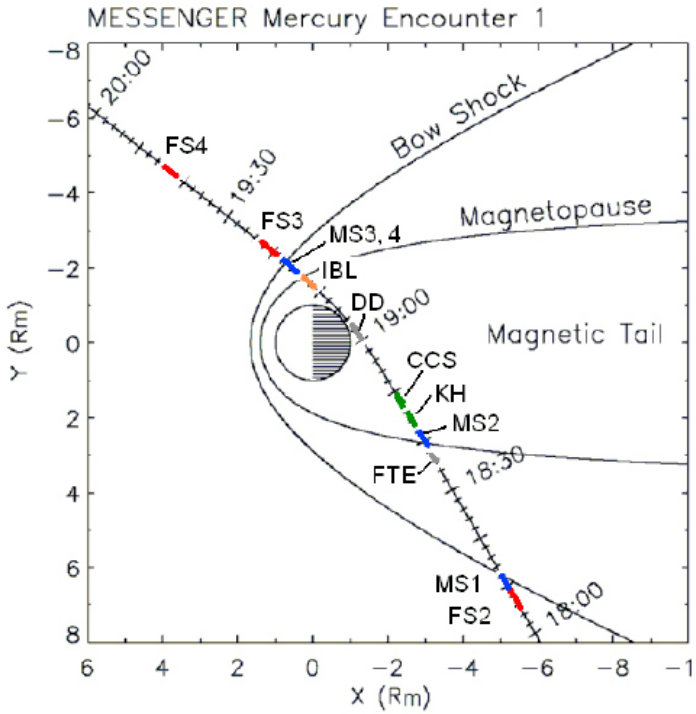


- ✓ low-altitude point: 313 km from the Venus' surface
- ✓ crossing the foreshock region and the inner induced magnetosphere
- ✓ **interplanetary magnetic field comparable with the Venus' induced one**

MERCURY FLYBY

- MESSENGER → January 14th, 2008: crossing several regions

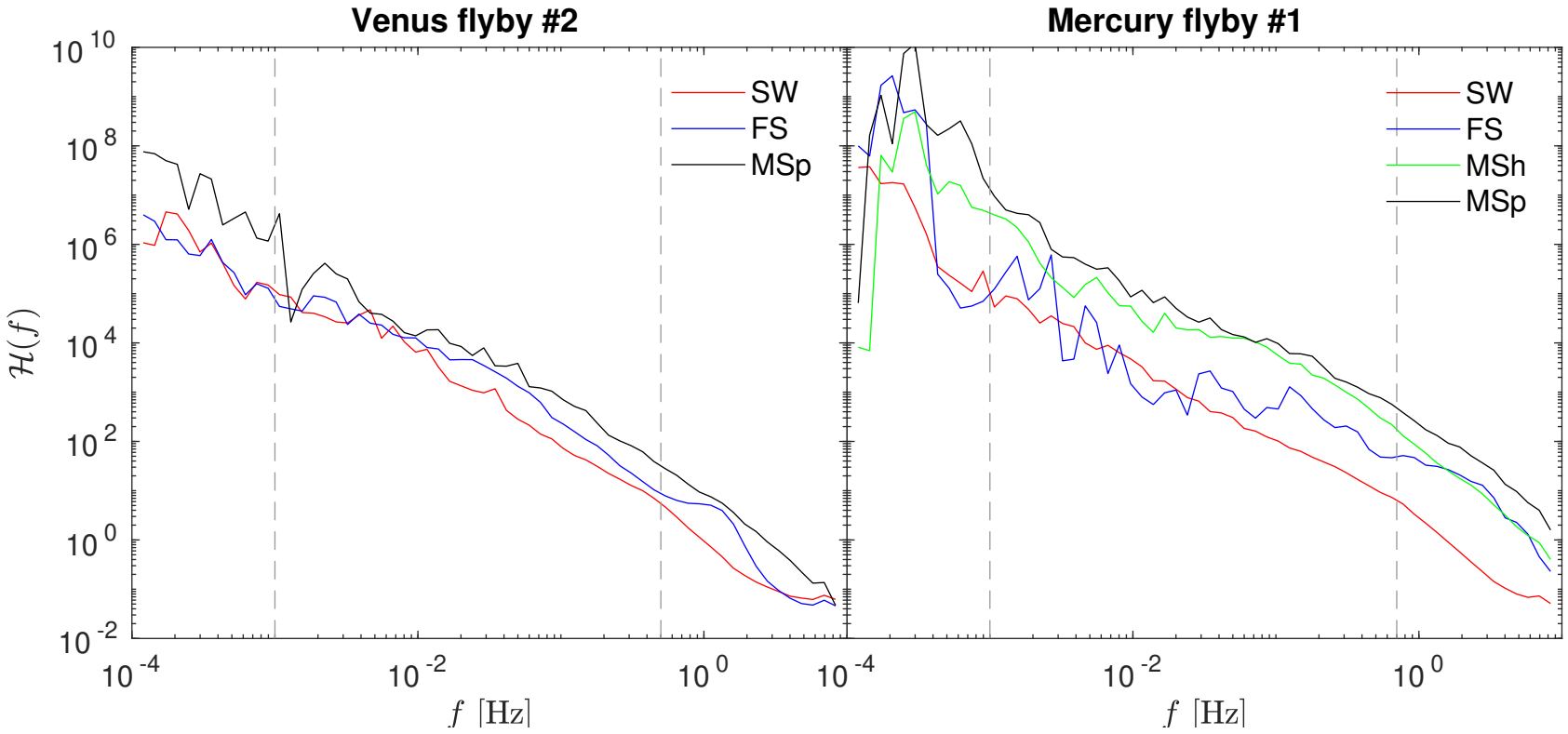




✓ **a clear transition is found**, more marked with respect to the Venus' magnetosphere

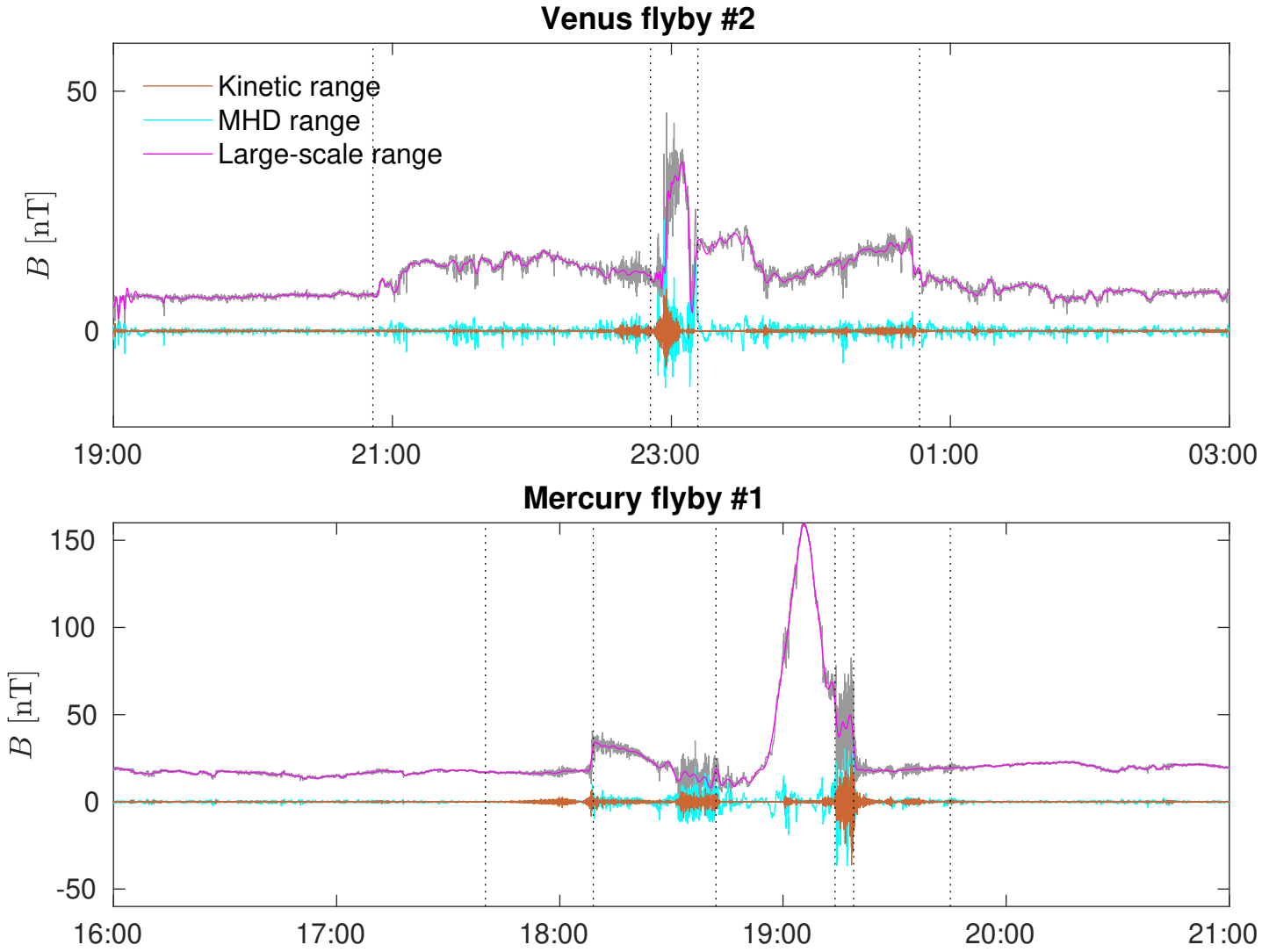
✓ low-altitude point: 200 km from the Mercury surface

✓ crossing the foreshock, the magnetosheath and the inner magnetosphere

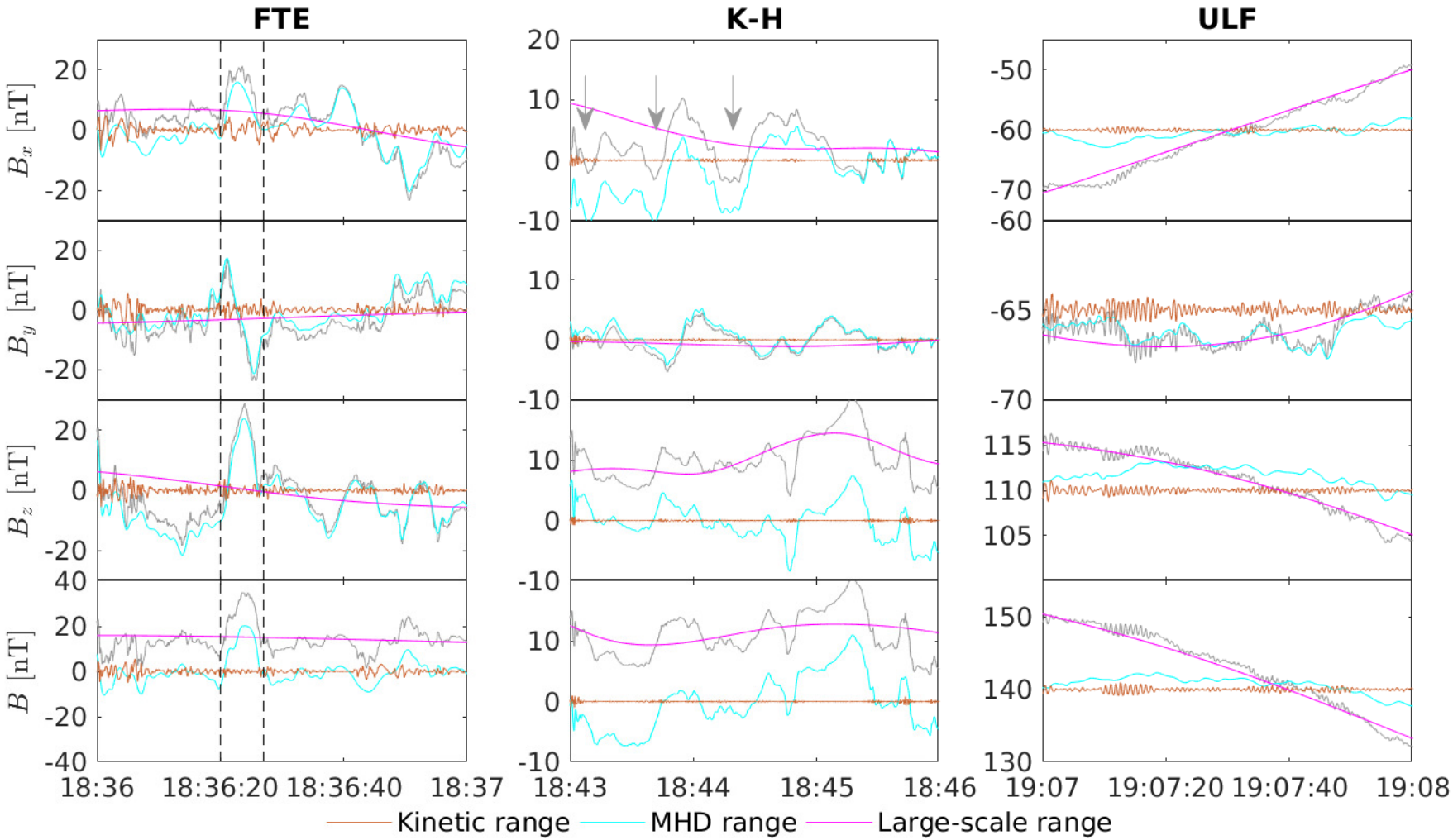


SW: solar wind - FS: foreshock - MSh: magnetosheath - MSp: magnetosphere

- ✓ **three different spectral scalings** have been found ⇒ **three different regimes** in each region crossed during the flyby
- ✓ $\beta \in [3/2, 5/3]$ when $f \in [3 \times 10^{-3}, 6 \times 10^{-1}]$ Hz ⇒ **inertial range dynamics**
- ✓ different frequency breaks positions ⇒ due to the solar wind expansion?
- ✓ **less steep scaling at large scales** ⇒ large-scale magnetic field



- ✓ ion-kinetic processes characterize the MSheath regions of Mercury and the inner induced Msphere of Venus
- ✓ intermittent features characterize the MHD range, amplifying within the MSheath
- ✓ the large-scale dynamics reproduces the "macroscale" magnetospheres



- ✓ the flux transfer event (FTE) and the Kelvin-Helmholtz (K-H) vortices are well reproduced by summing up empirical modes within the MHD range
- ✓ ULF activity is reproduced by summing up empirical modes within the kinetic range

Conclusions

- characterization of the structure and **dynamics of planetary magnetic field at different scales** $\Rightarrow$ investigation of physical processes
- **identification of different planetary regions** by means of looking for scaling processes and energy distribution
- detecting the **"effective" planetary magnetic field** and using for **modeling purposes**

Tips

- deeper investigations are required on different parameters (particle distributions)
- ***BepiColombo could provide both high-resolution measurements and particle distributions***, thus helping us for a deeper characterization of planetary environments
- interplanetary features far and near planetary environments $\Rightarrow$ **cruise vs. flybys**

- ✓ **is the solar wind changed by the interaction with planetary magnetic fields?**
- ✓ **where is the bow shock formed near planetary environments?**
- ✓ **what about when solar structures encounter small magnetized environment?**

- **multi-spacecraft combined observations** will allow to simultaneously monitor solar wind and planetary environments