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Spectroscopic signatures of magnetospheric accretion in Herbig Ae/Be stars

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Herbig Ae/Be stars (HAeBes) are pre-main-sequence (PMS) objects with pronounced emission line features and an infrared (IR) excess indicative of dust in their circumstellar (CS) disks. These stars are intermediate-mass analogues of T Tauri stars, but with convectively stable interiors that do not support dynamo action as found in the fully convective T Tauri stars. From detailed magnetohydrodynamical models, it is expected that magnetic fields in low-mass PMS objects funnel material from the disk towards the star and launch a collimated bipolar outflow. The star/CS interaction in classical T Tauri stars is well described by the magnetospheric accretion (MA) model, where the field truncates the disk at a distance of 5–10 stellar radii. However, it is still unclear how well this model can be applied to HAeBes, whose magnetic fields are roughly one order of magnitude weaker.

We monitor the variability detected in the red part of line profiles originating in (or close to) the region of the star/CS interaction.

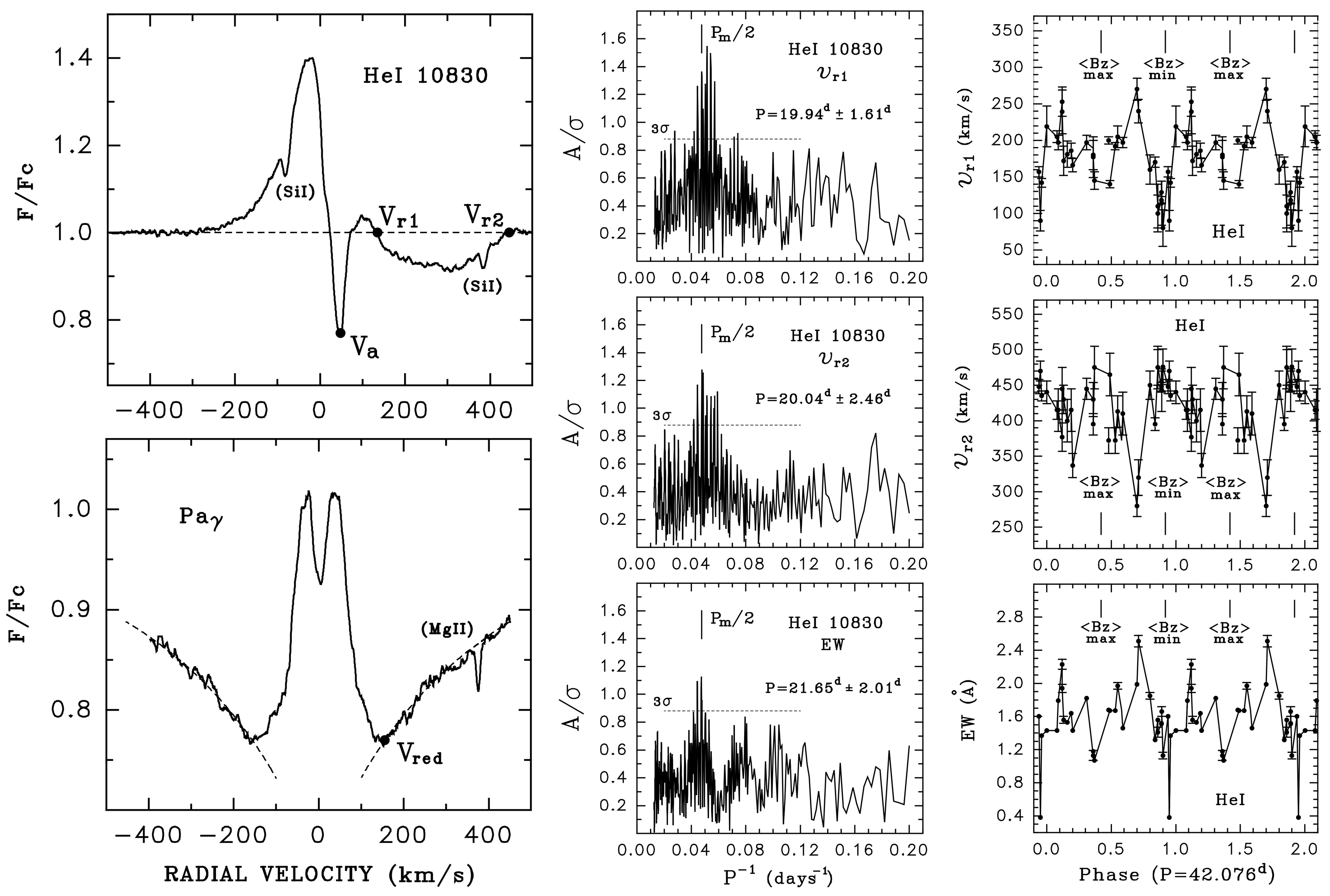
- If the orientation of the disk deviates from an edge-on orientation, the detected variability can be considered as a signature of the accretion flows intersecting the line-of-sight at intermediate and high latitudes.
- This can take place only for MA accretion, when the accreted material is carried out from the equatorial plane along closed magnetic field lines inside the magnetosphere to higher latitudes.

We also search for rotational modulation in spectral line profiles.

- If the star has a significant magnetosphere and the magnetic axis is not aligned with the rotation axis, the accreted flow will be governed by the magnetic field inside the magnetosphere and the accretion shock on the stellar surface near the magnetic pole will be observed as an azimuthal inhomogeneity.
- Such an inhomogeneity rotates together with the star and modulates the line shape with a period equal to the rotation period of the star.

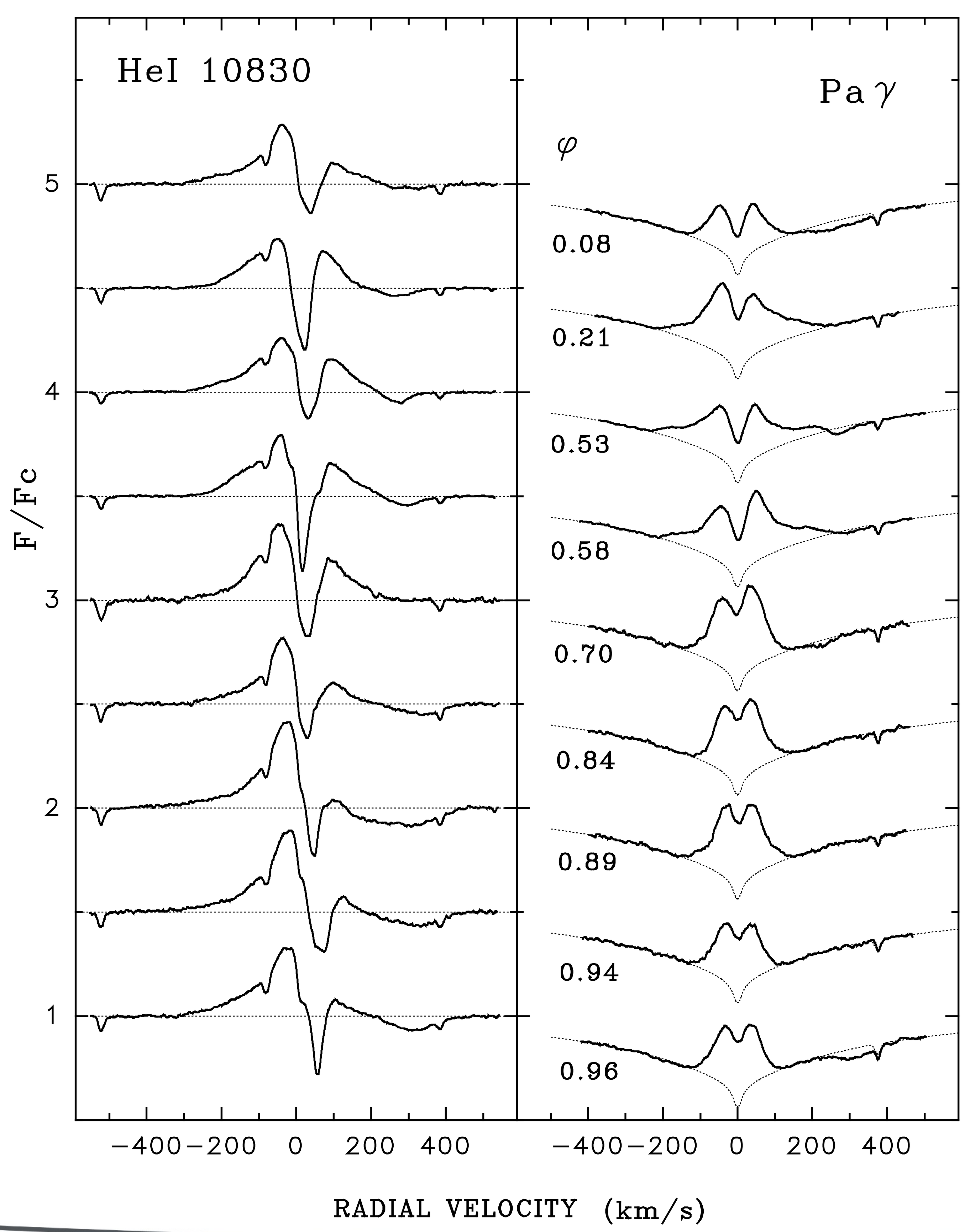
Investigation is done using two near-IR lines, HeI λ10,830 and Paγ (at 10,938Å), that have important role in probing the structure of the accretion region of PMS objects (Edwards et al. 2006 ApJ, 646, 319).

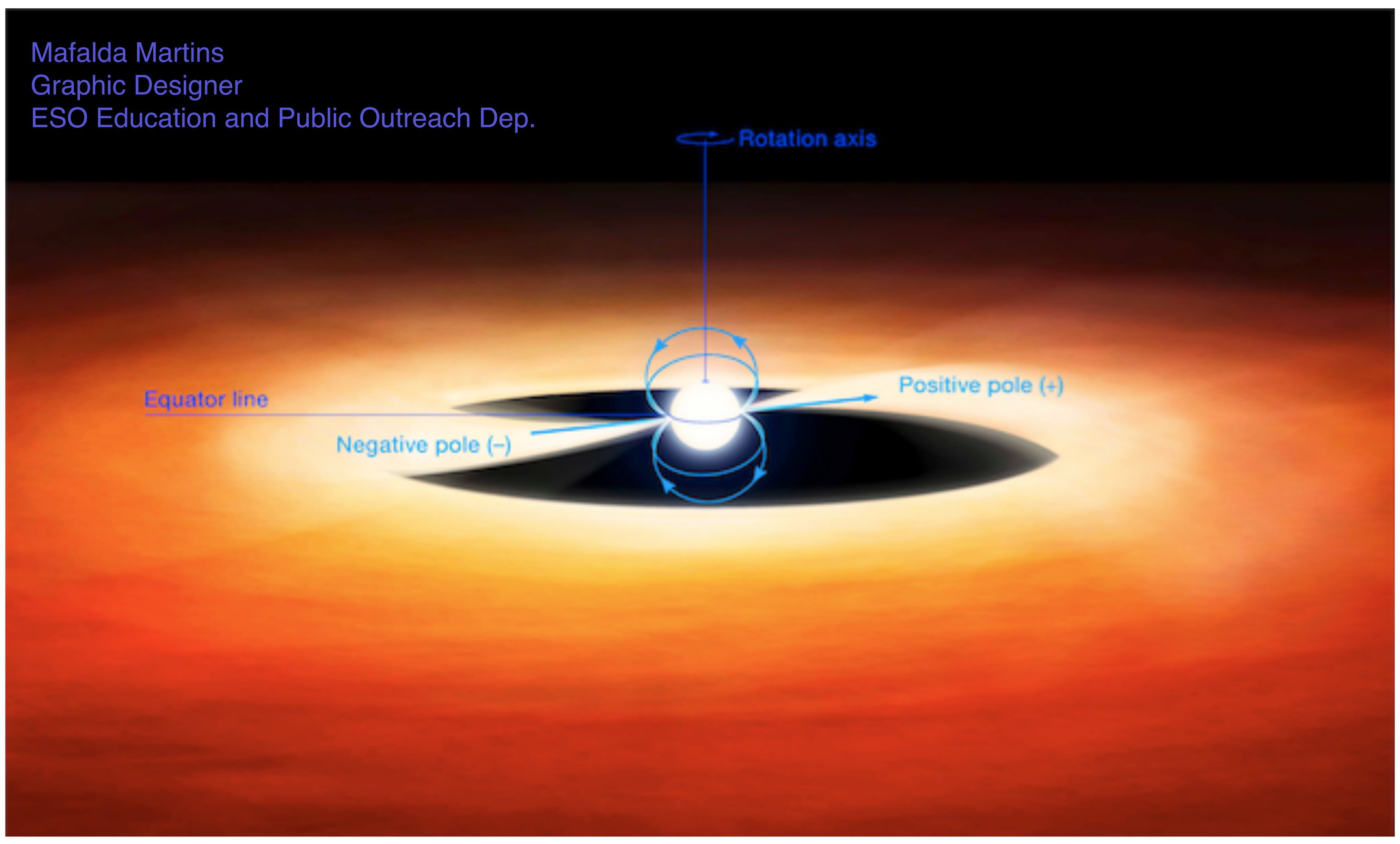
We conclude that the phase dependencies of all chosen line parameters are in good agreement with an MA model and with the magnetic field topology and orientation suggested by Hubrig et al. 2011 A&A, 525, L4. For more details, see Schöller et al. 2016, accepted for A&A.



Left: Spectral parameters of the He I λ10,830 and Paγ line profiles used in the quantitative analysis.
Middle: Examples of A/σ periodograms for the different line parameters. 3σ significance levels are marked by the dashed lines. Short vertical lines indicate the value corresponding to half of the magnetic rotation period ($P_m/2$ = 21d.038). The detected period values and their errors are given in each plot.
Right: Phase dependencies of different line parameters over the magnetic rotation period P_m= 42d.076. The initial phase φ = 0 corresponds to MJD 52797.4. Error bars are given for each value.

Line profiles of the He I λ10,830 and Paγ lines in HD 101412 CRIRES spectra. The rotation phases of the observations assuming the magnetic rotation period P_m= 42d.076 are presented close to the Paγ lines.





A schematic view of magnetospheric accretion in HD 101412. The accreted matter falls onto the star in regions close to the magnetic poles intersecting the line-of-sight twice during the rotation cycle.