

Exocomets in UV spectroscopy : Measuring C/Fe ratios with HST

Théo Vrignaud

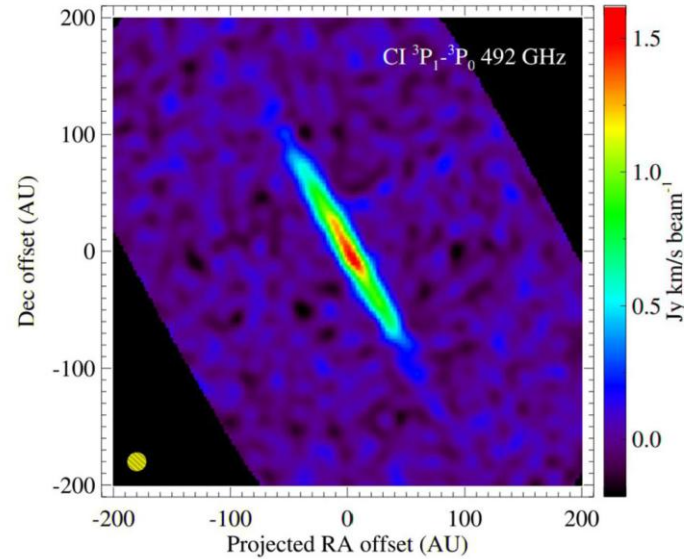
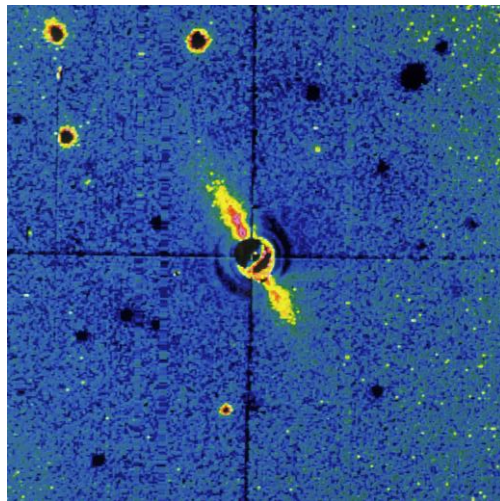
Institut d'Astrophysique de Paris

I. Introduction:
From **debris discs** to **exocomets**

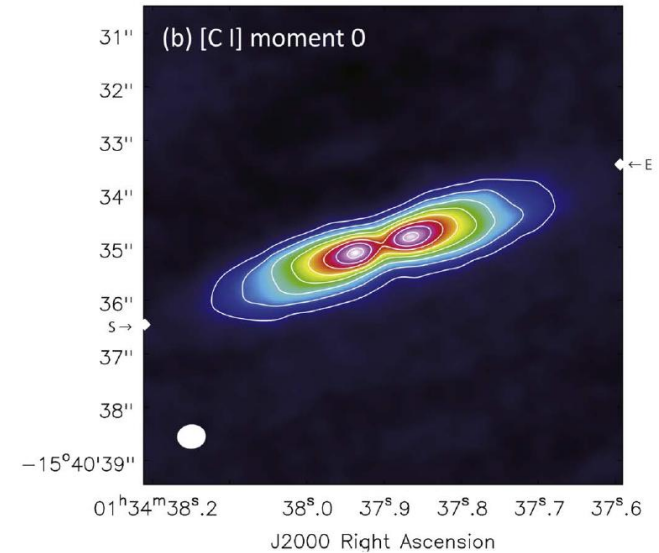
Introduction

Debris discs

Some young stars (10-50 Myr) host **debris discs**, composed of dust and gas :



Beta Pictoris (Smith & Terrile 1984, Cataldi+ 2018)



49 Cet (Higushi+ 2019)

Debris discs are...

Fainter and **older** than protoplanetary discs

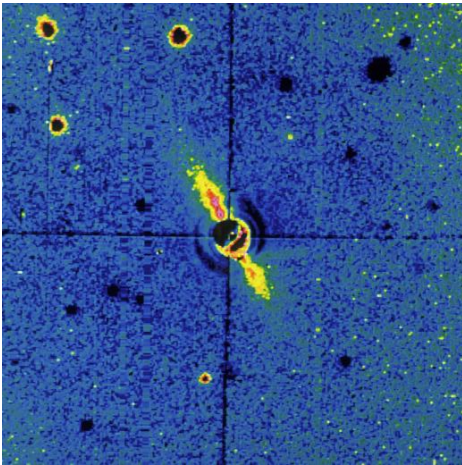
Laboratory for the **last stages of planetary formation**

Introduction

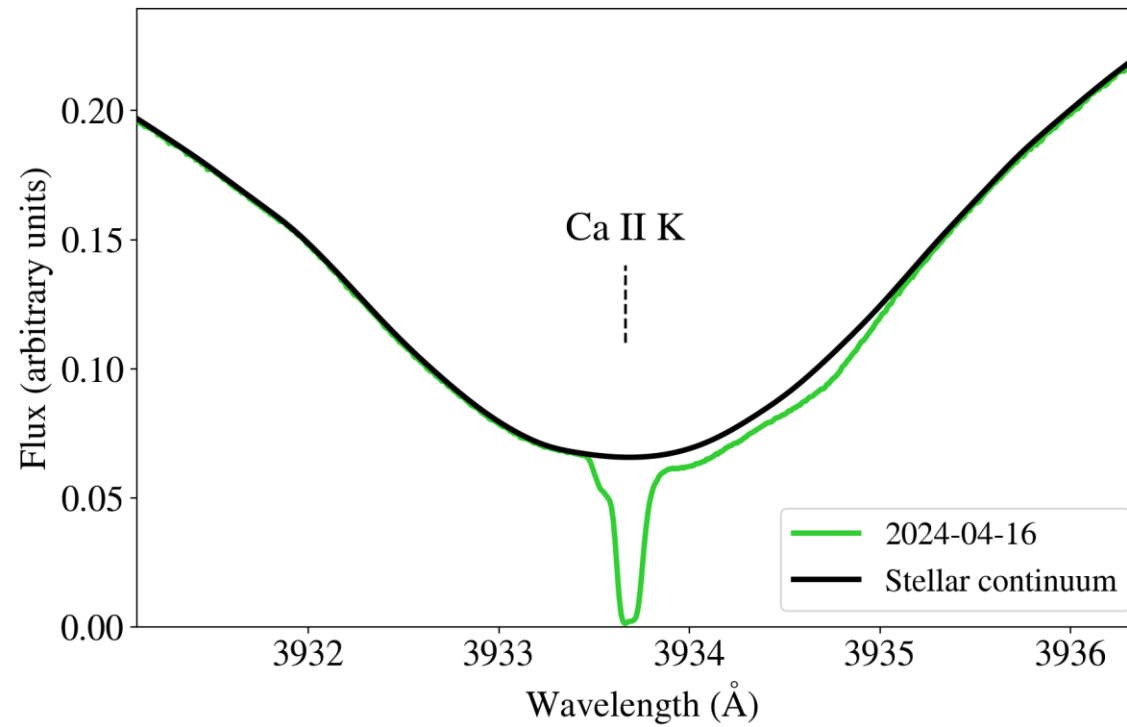
Spectroscopy of debris discs

Debris discs are particularly useful when they are seen **edge-on**, like **Beta Pictoris**:

β pic disc
(Smith & Terile 1984)



β pic spectrum (HARPS)

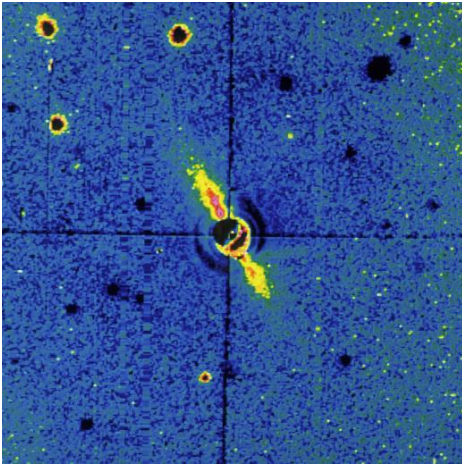


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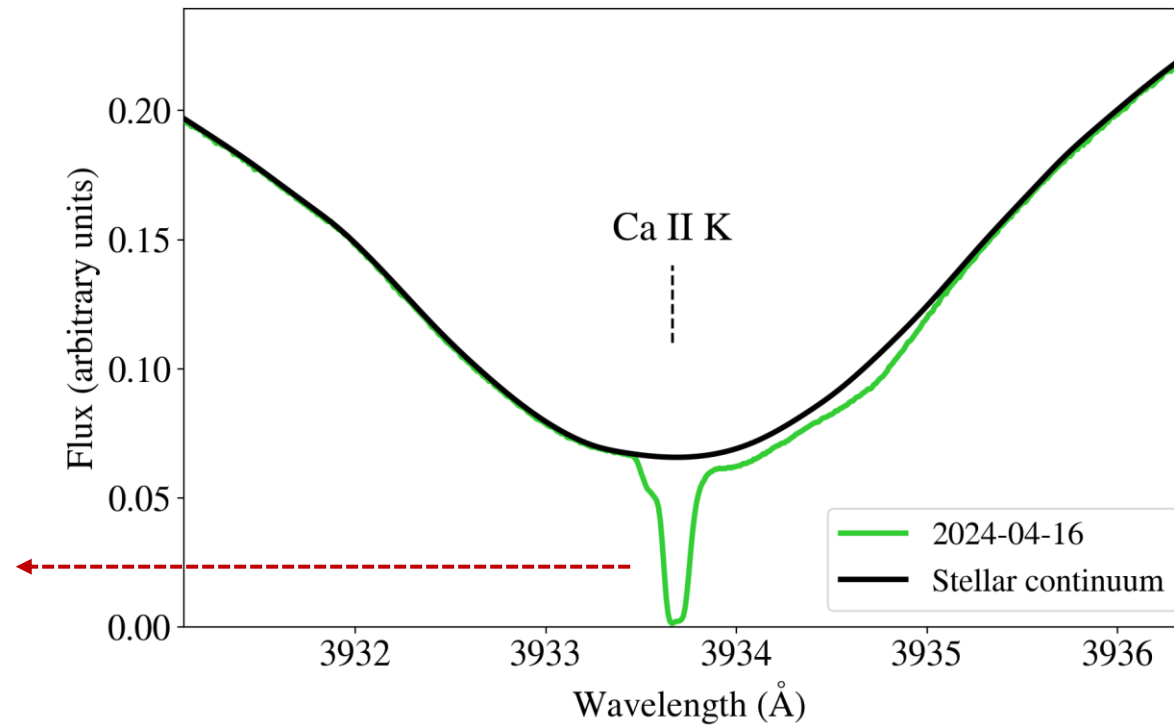
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Stable absorption
from the **gaseous disk**

≈ 50 au from the star

β pic spectrum (HARPS)

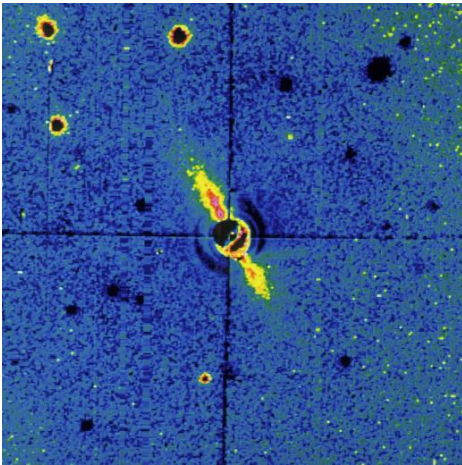


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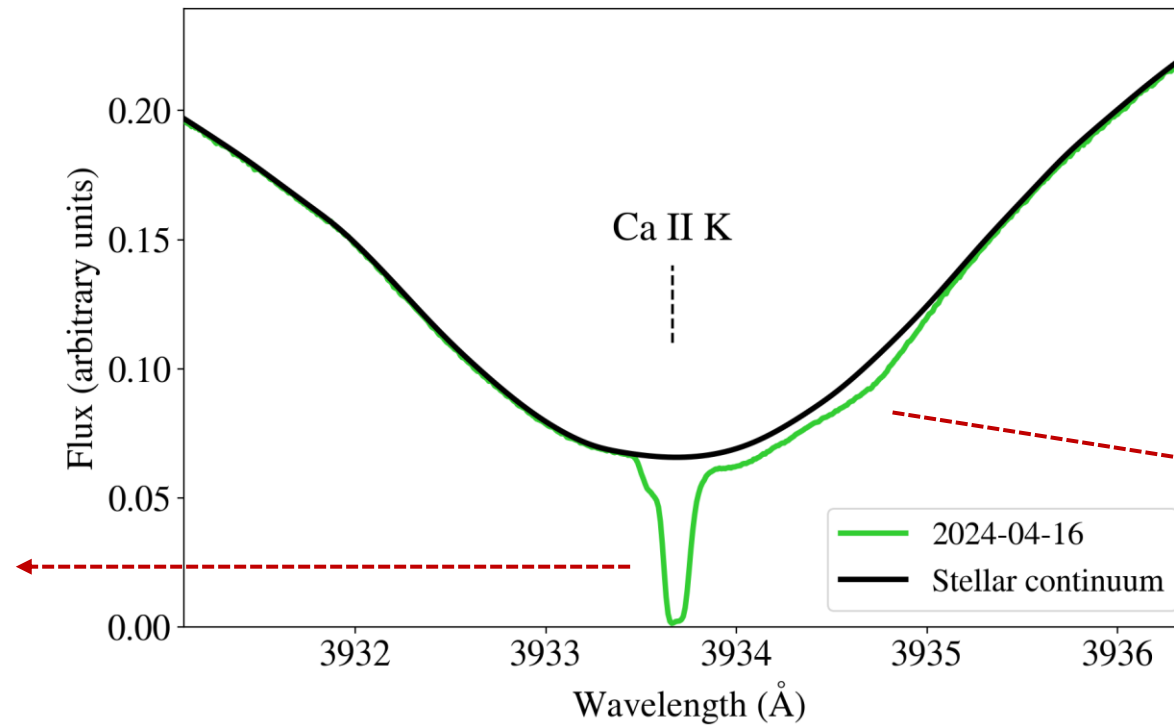
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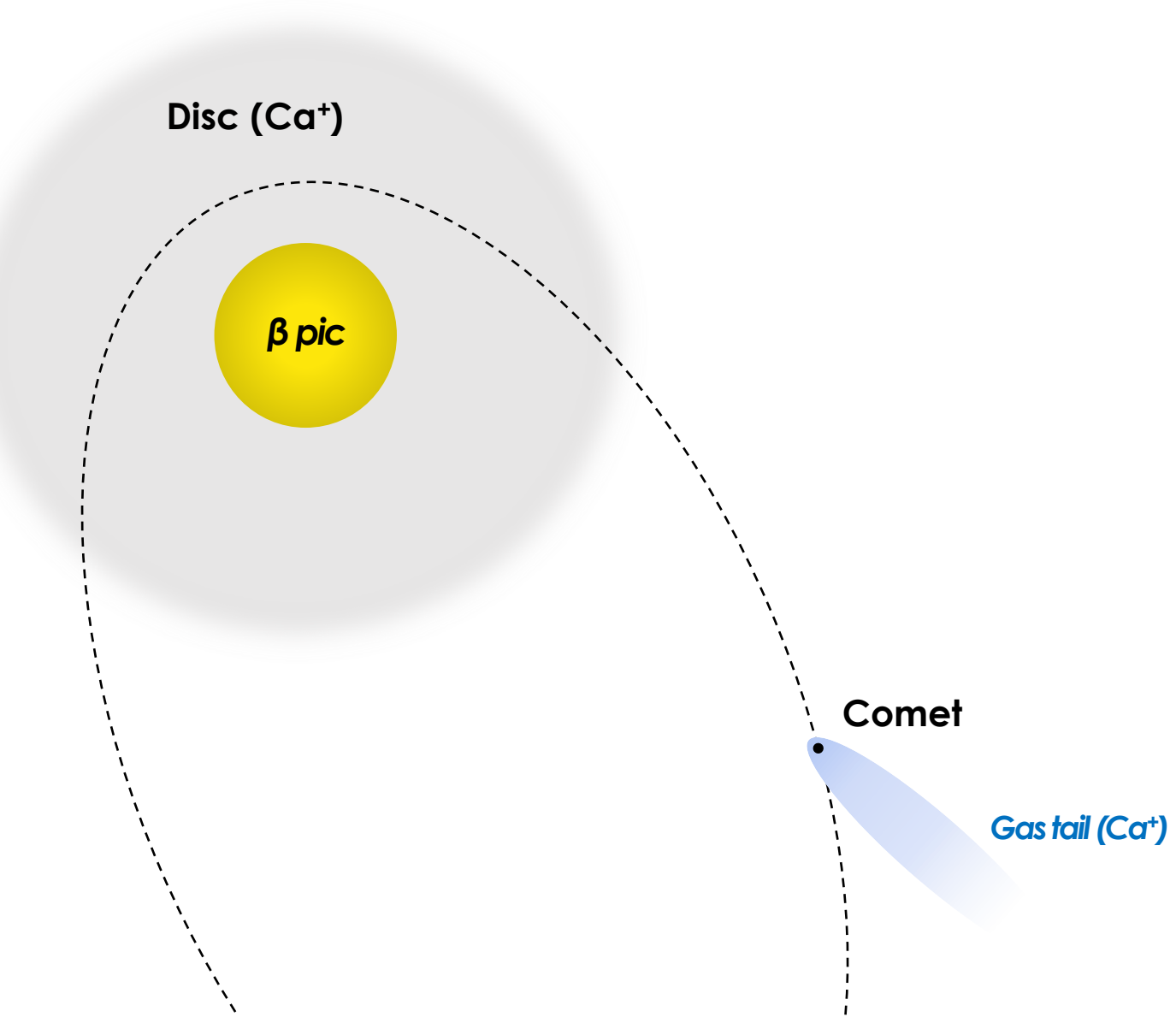
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Variable absorptions
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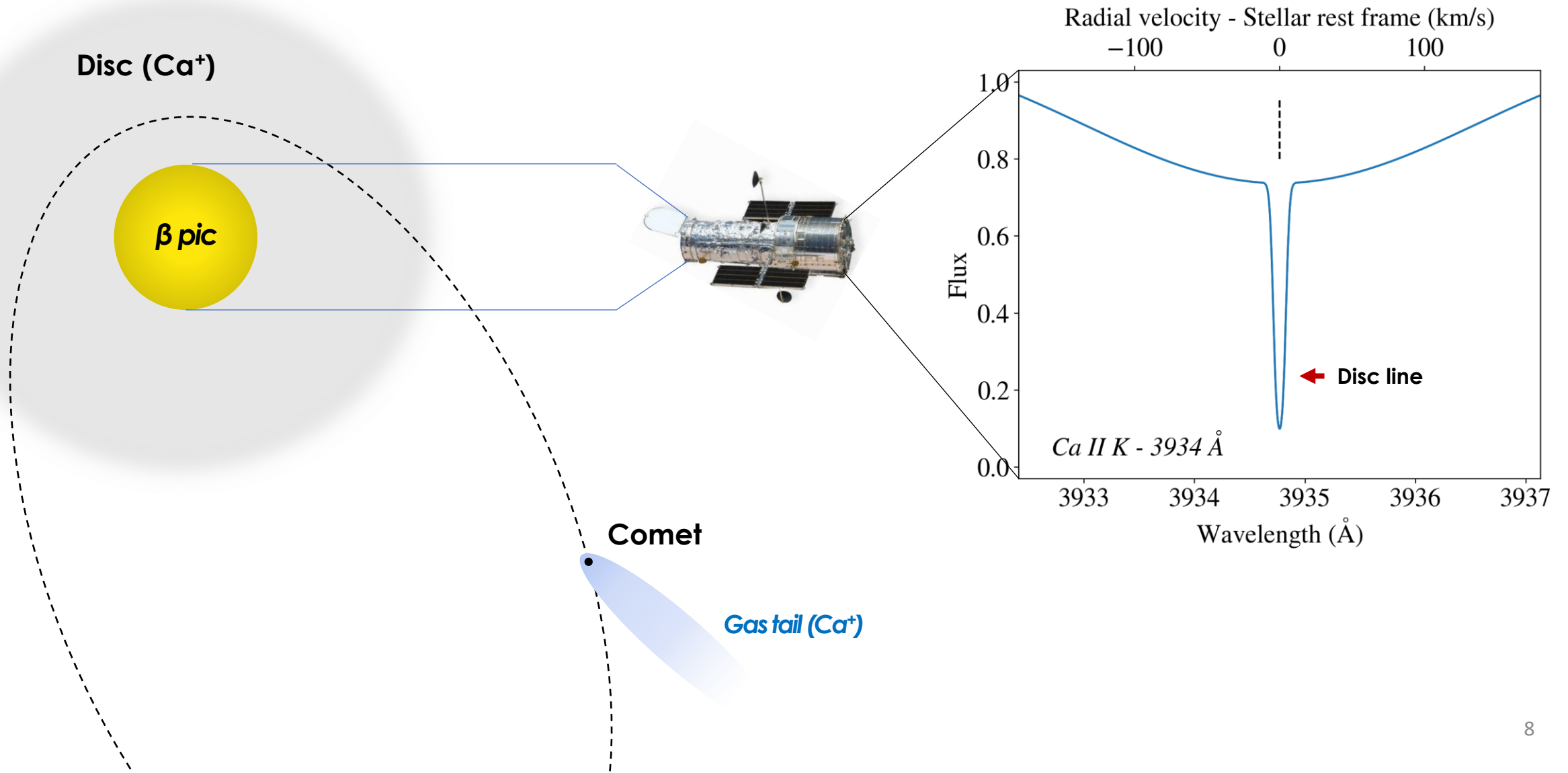
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Detecting exocomets



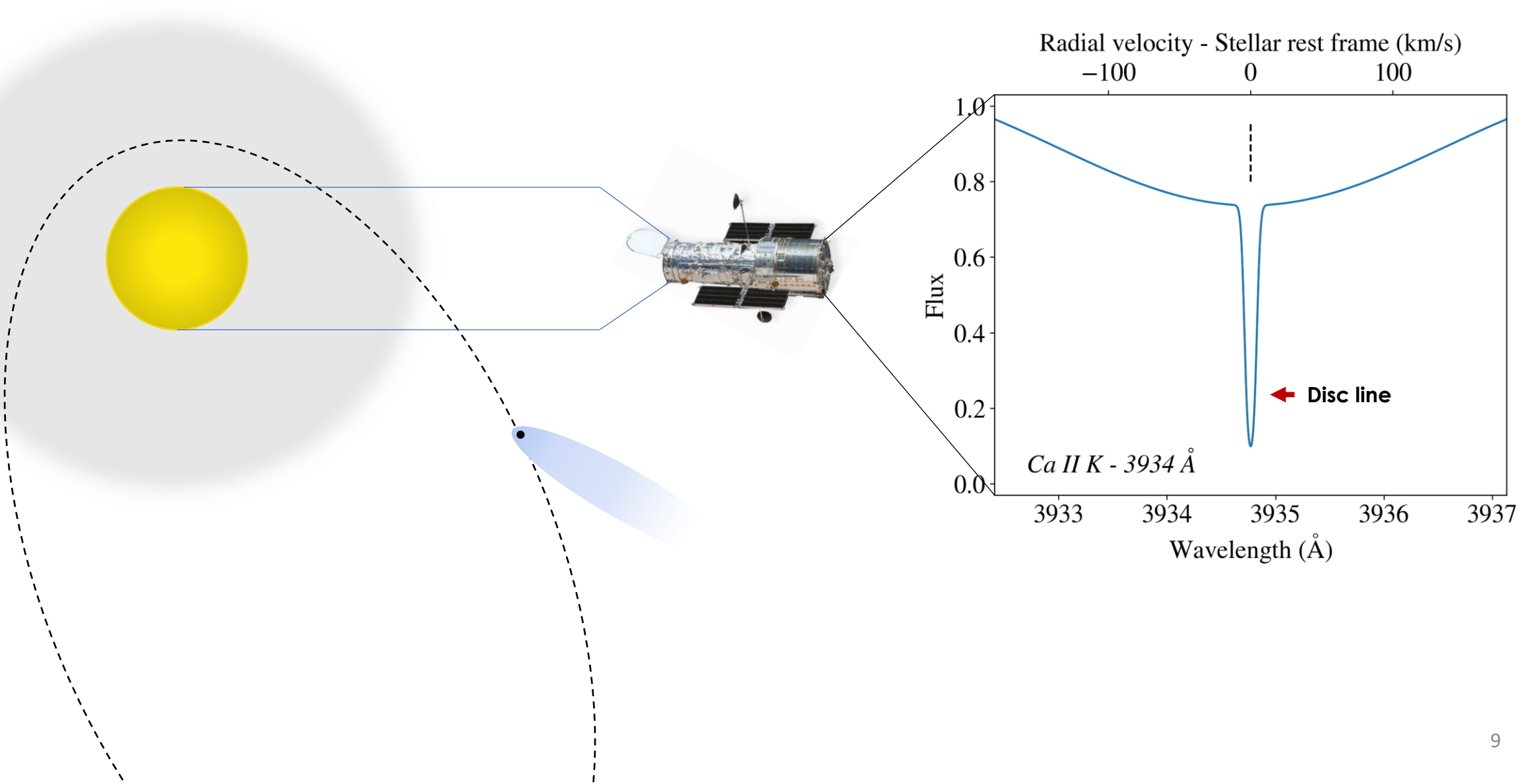
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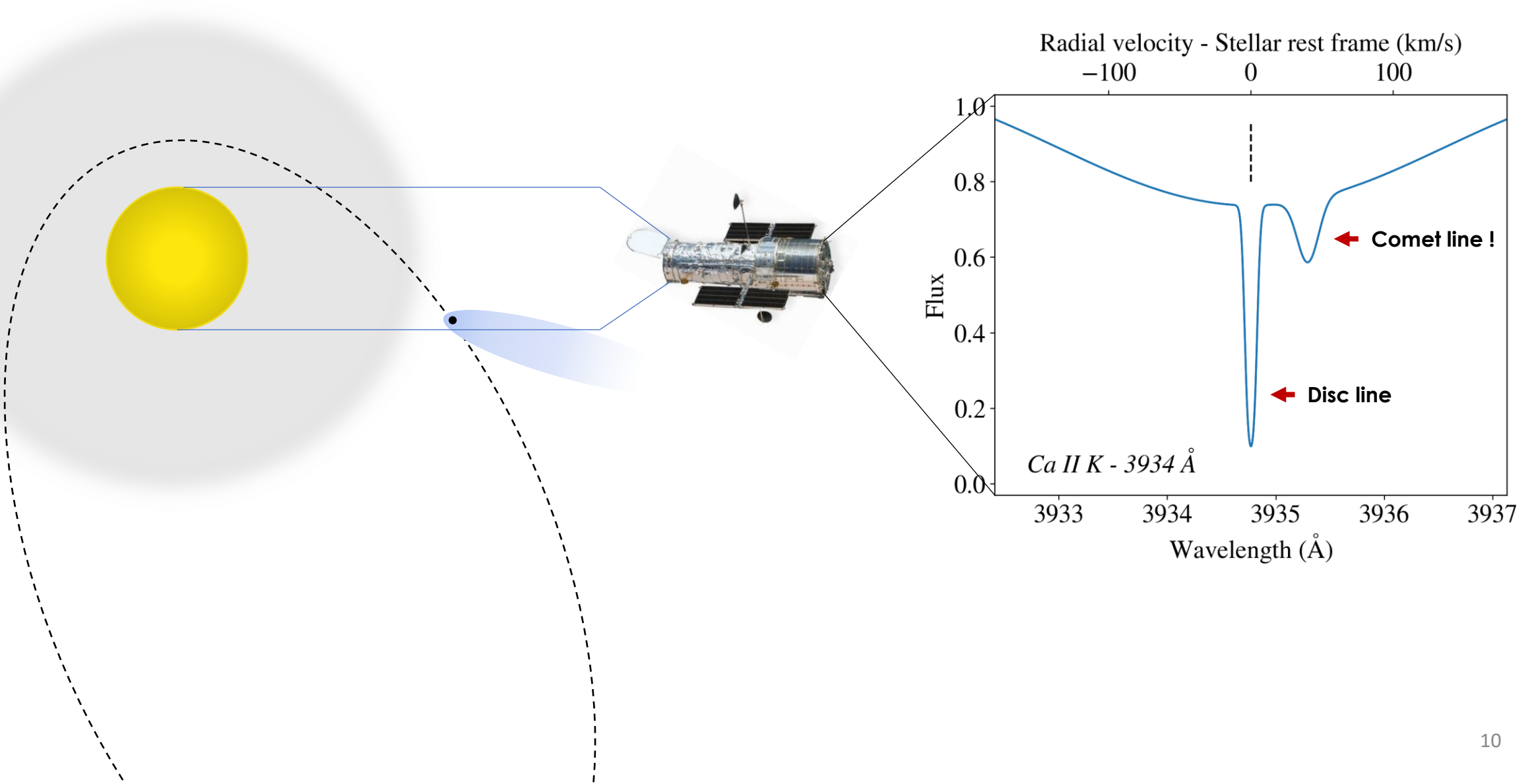
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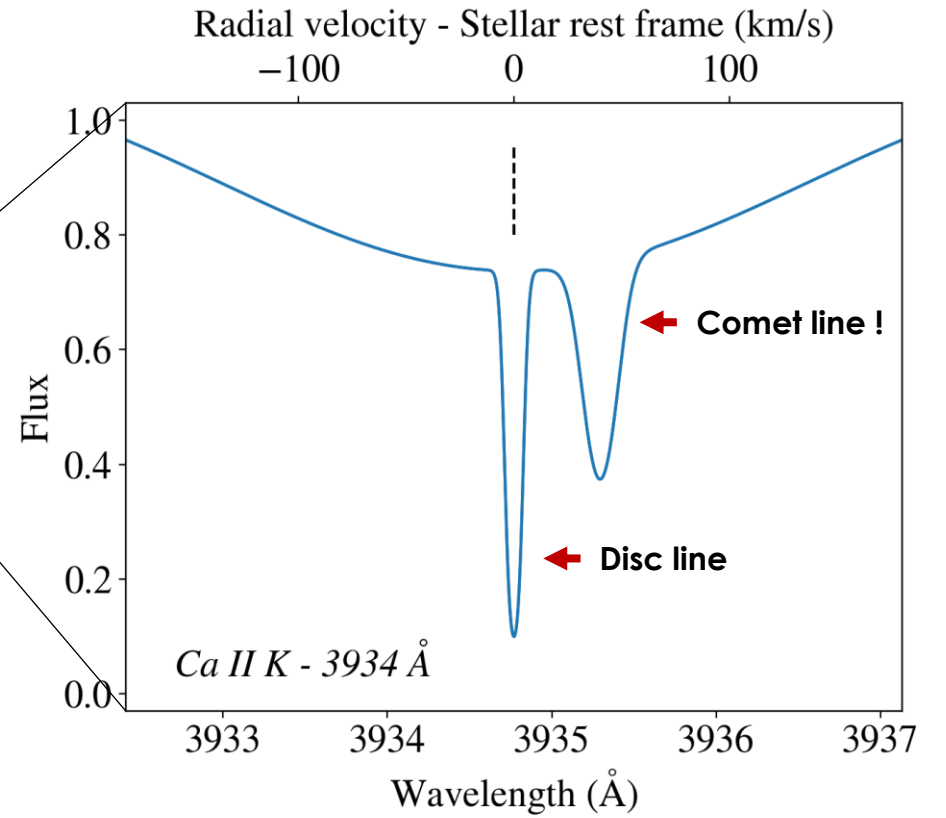
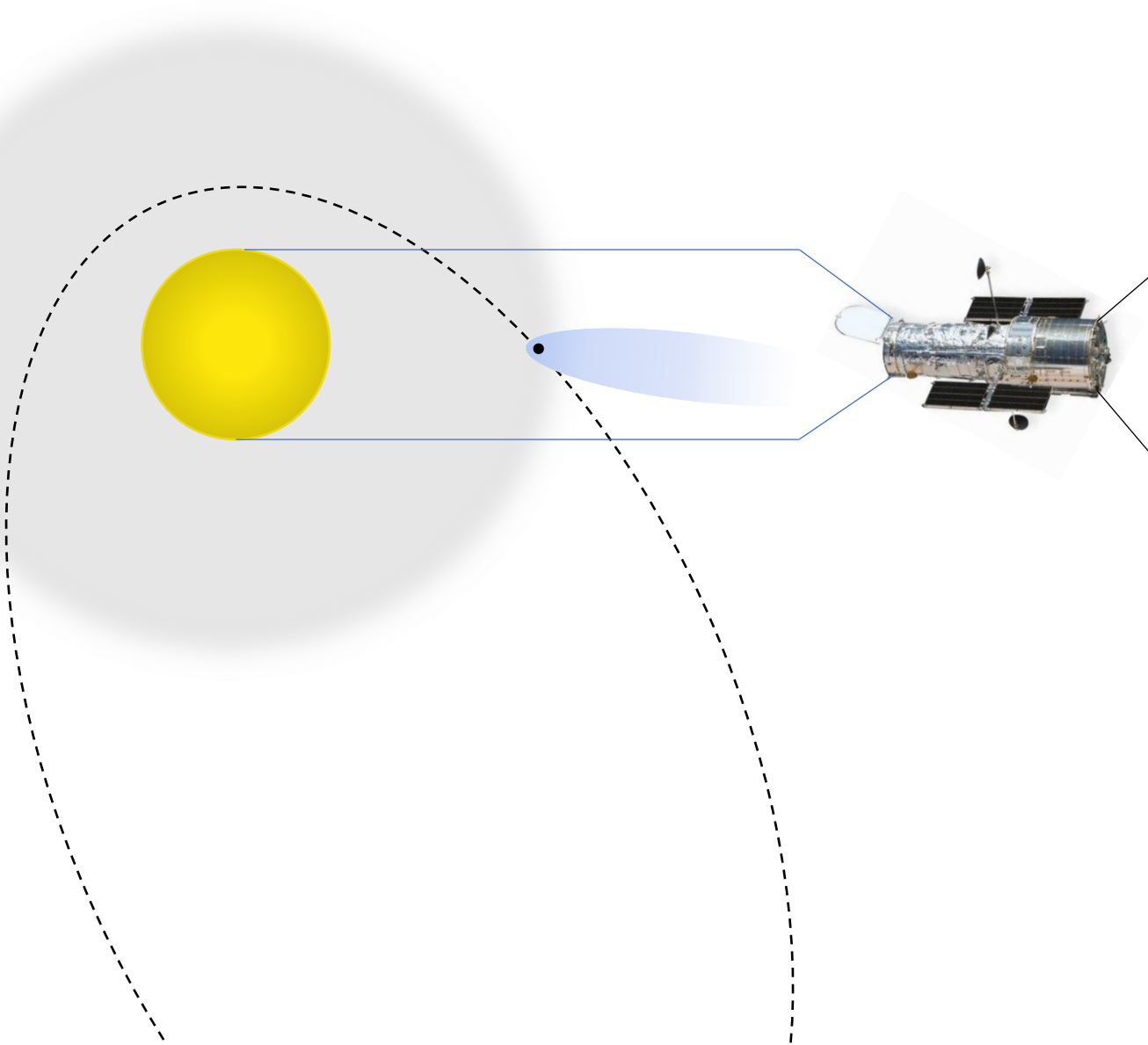
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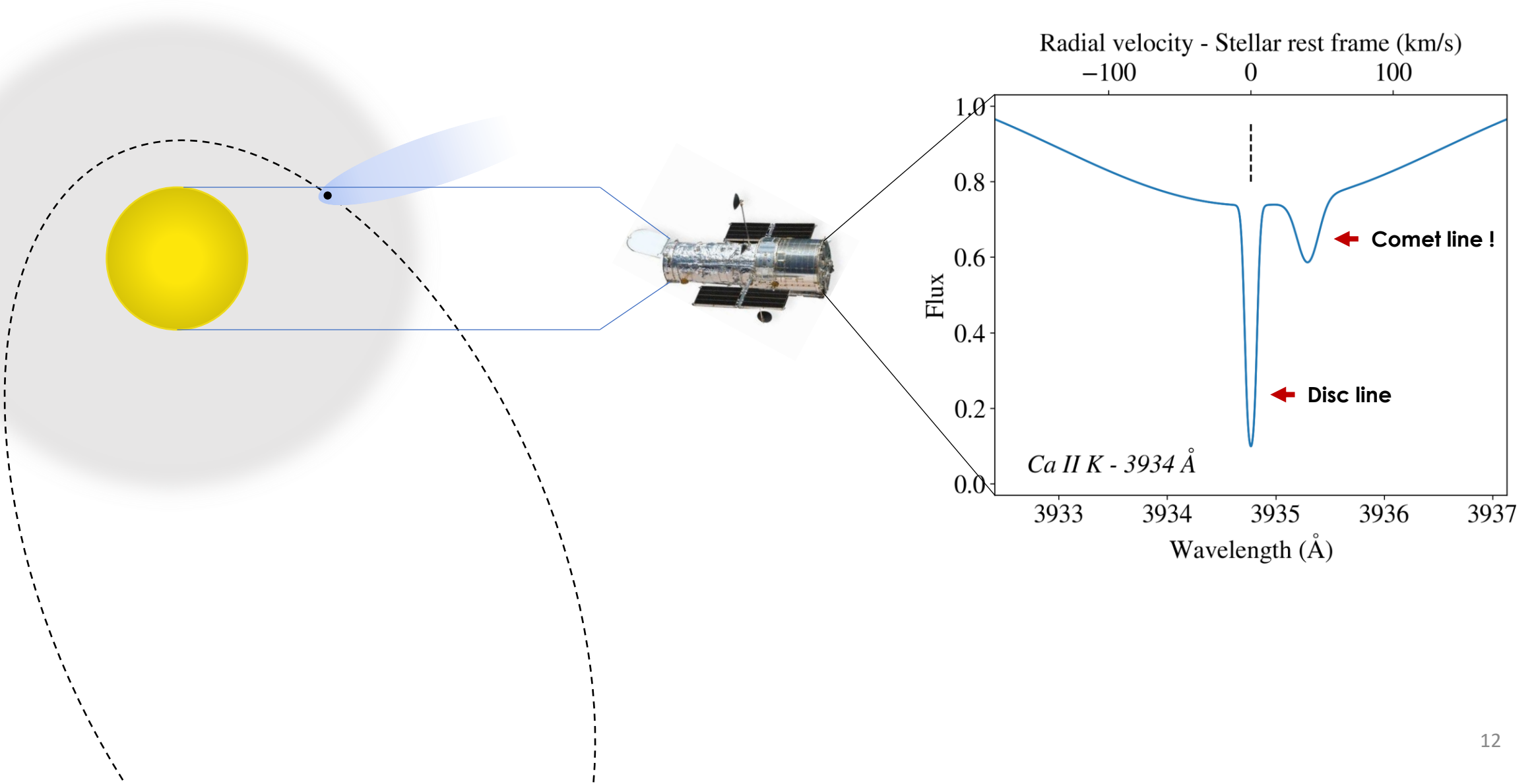
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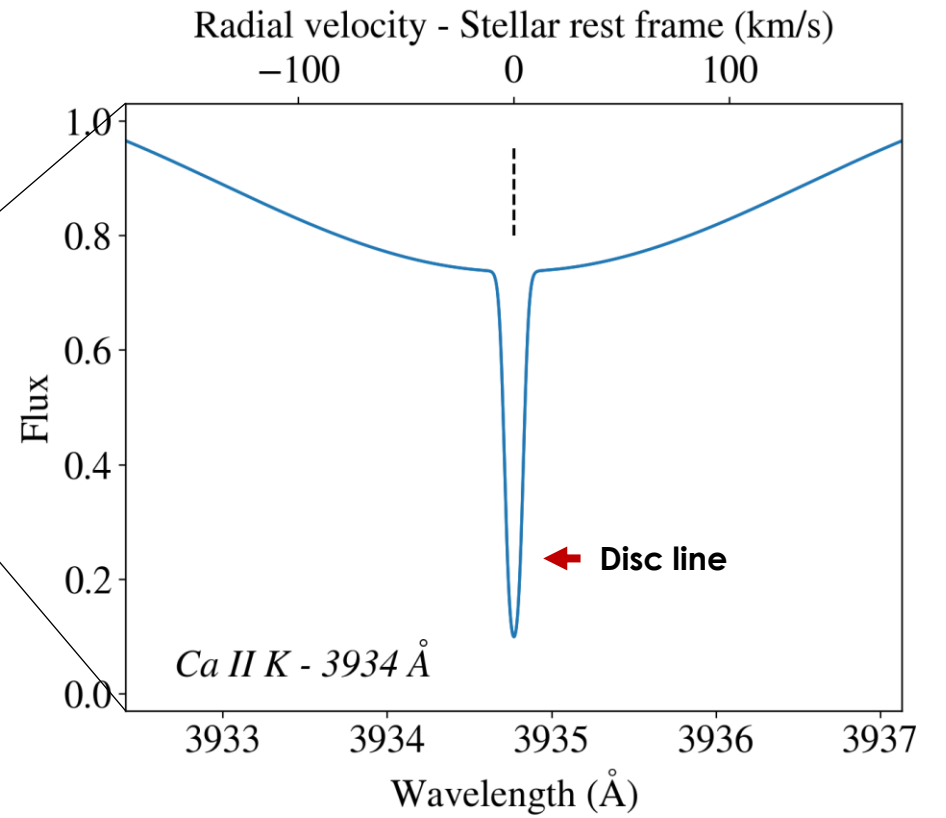
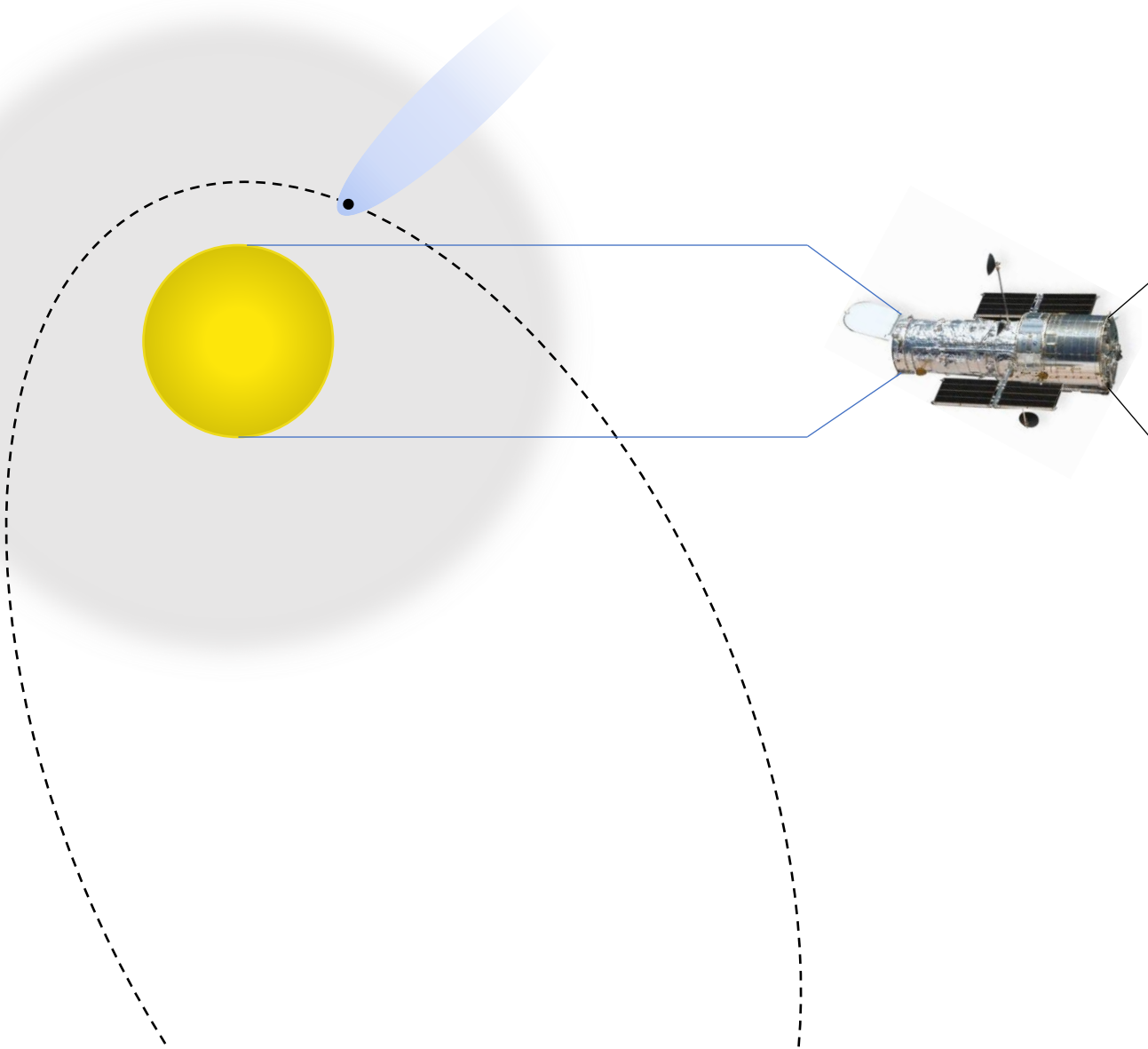
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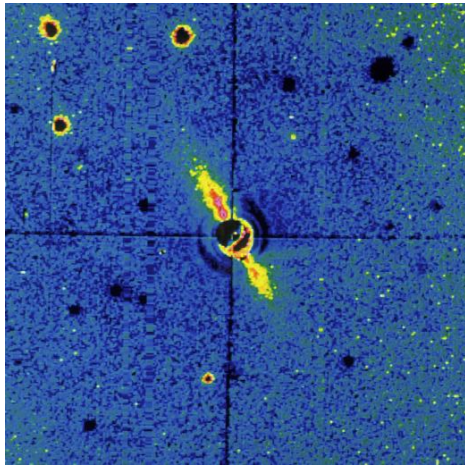


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Spectroscopy of debris discs

Beta Pictoris is **ALWAYS** occulted by exocomets!

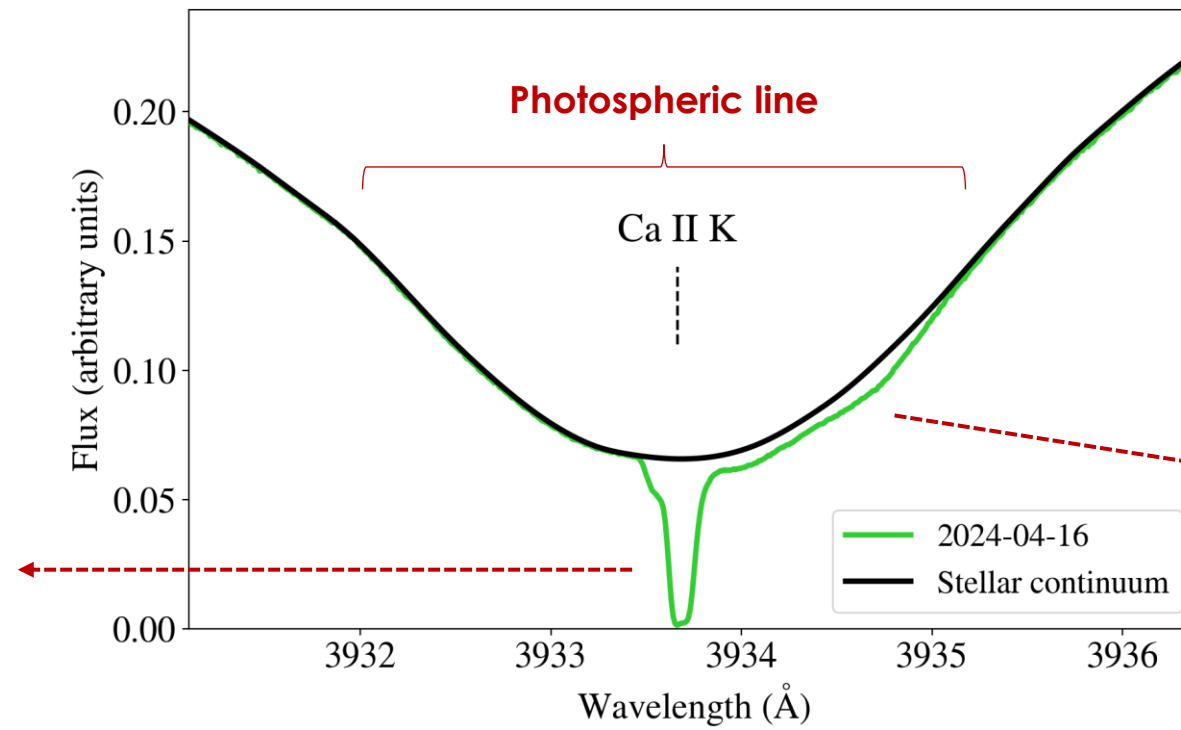
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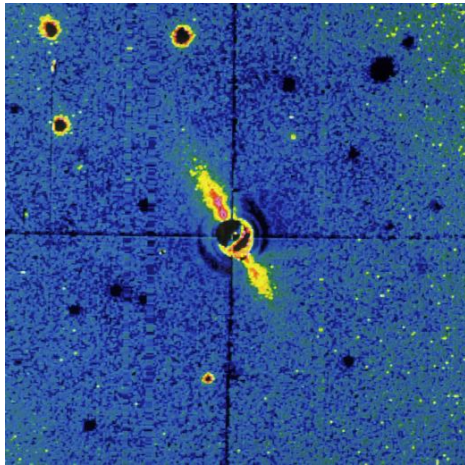
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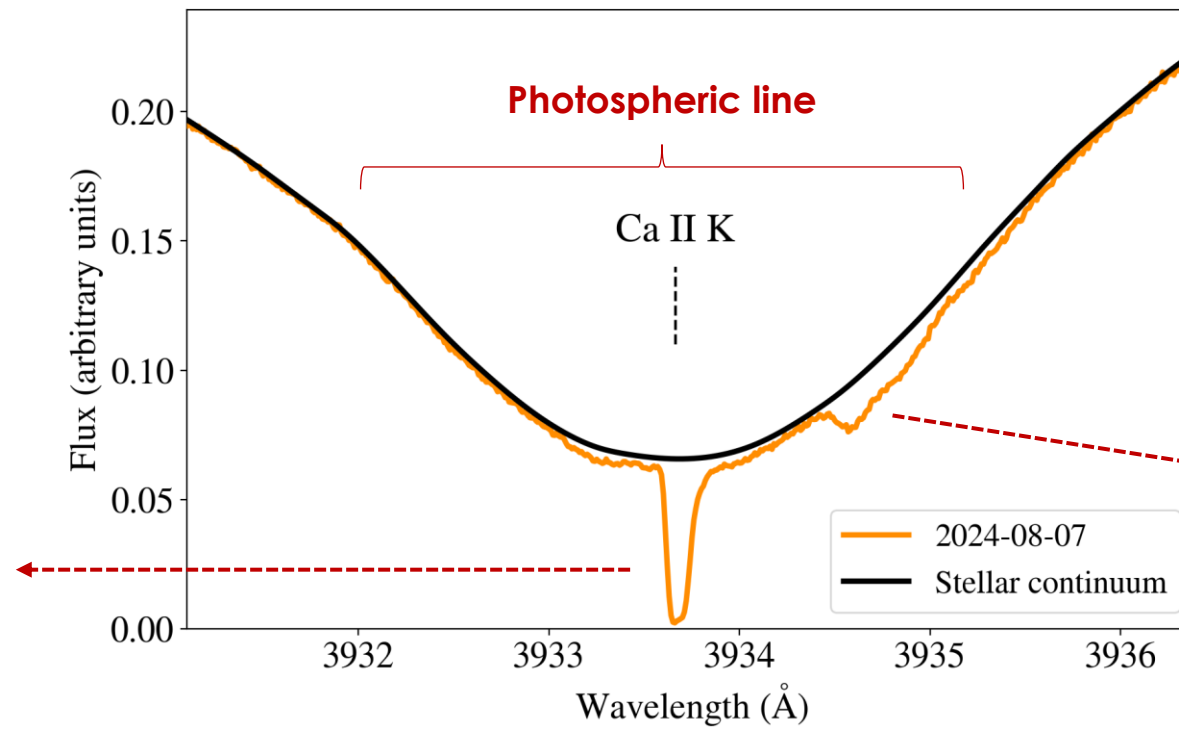
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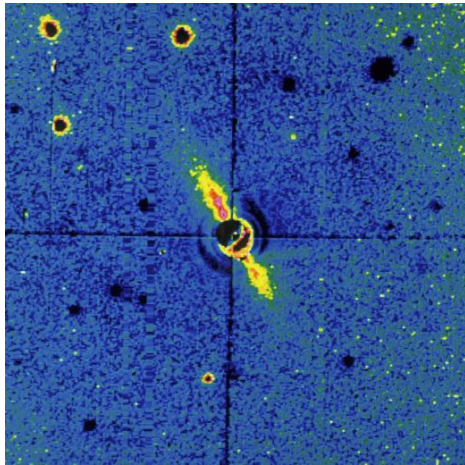
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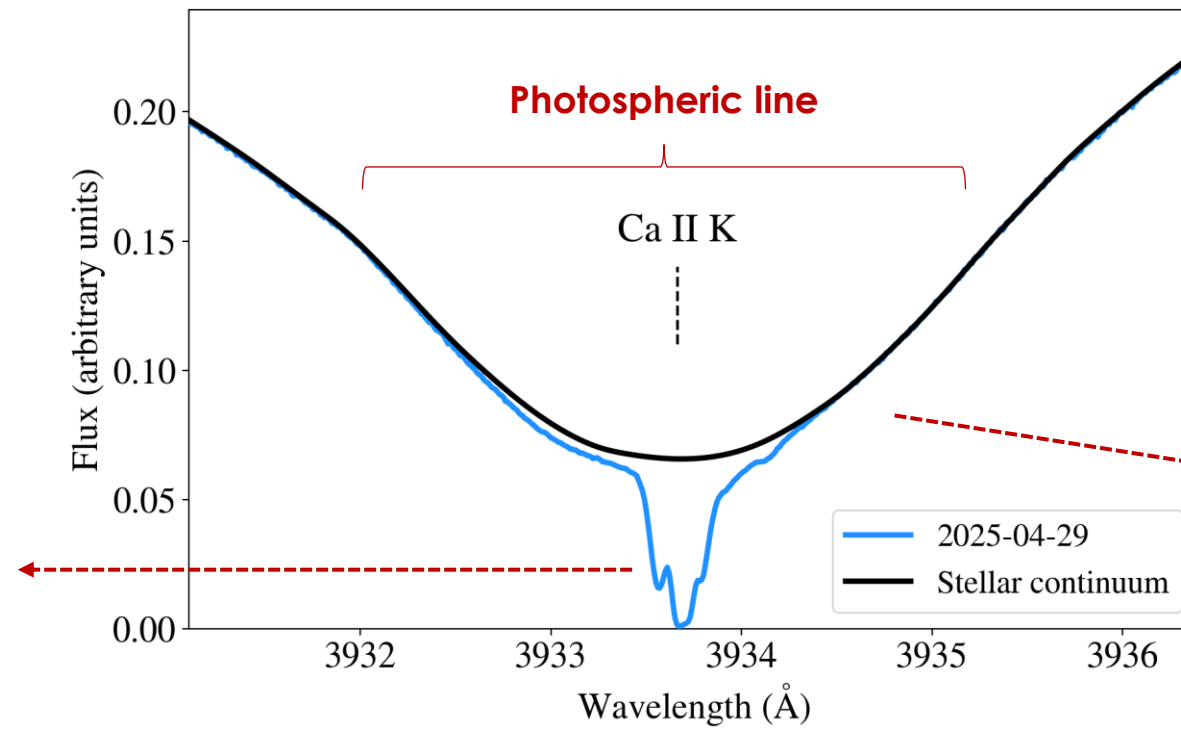
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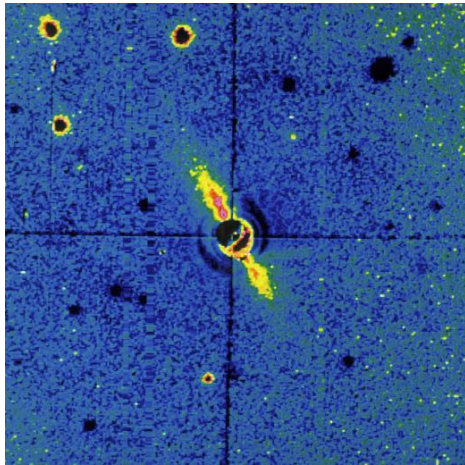
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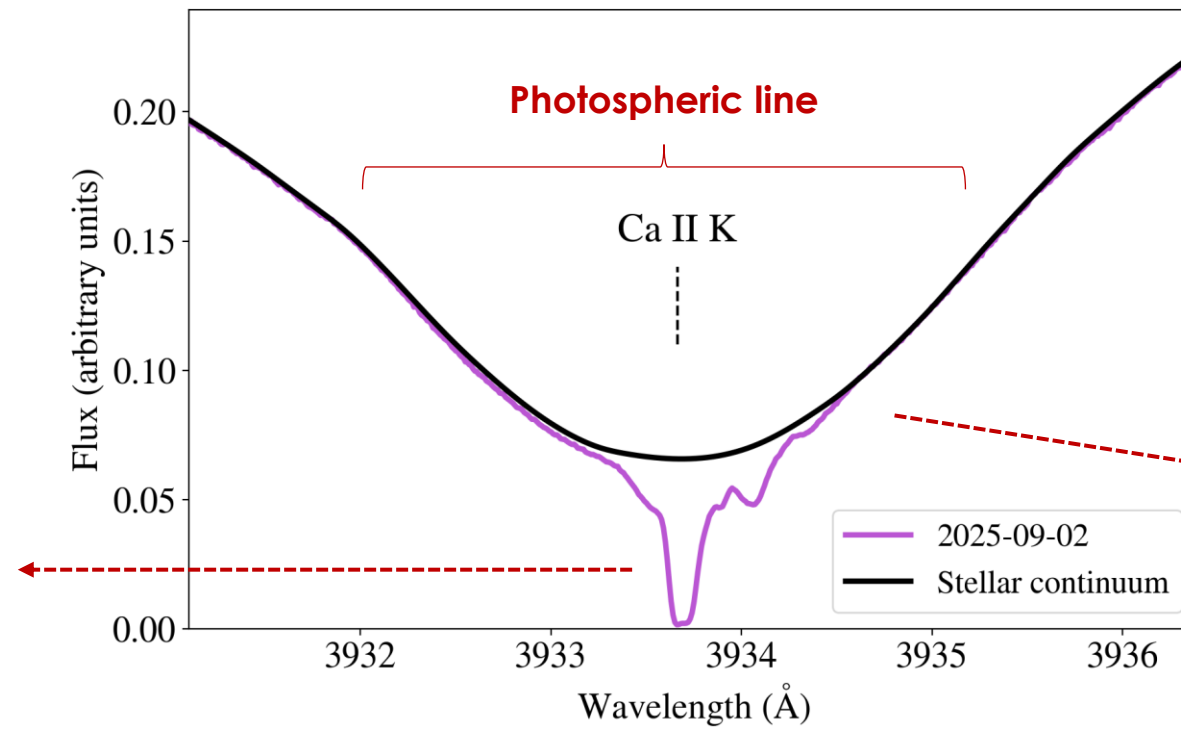
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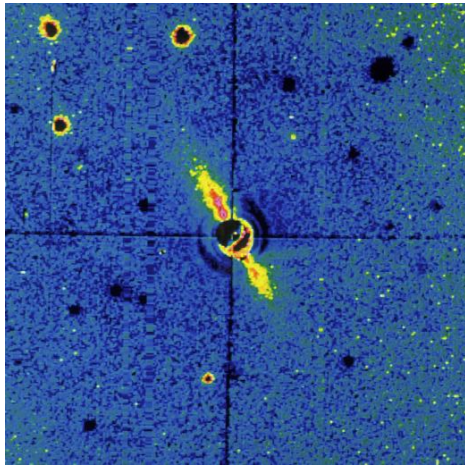
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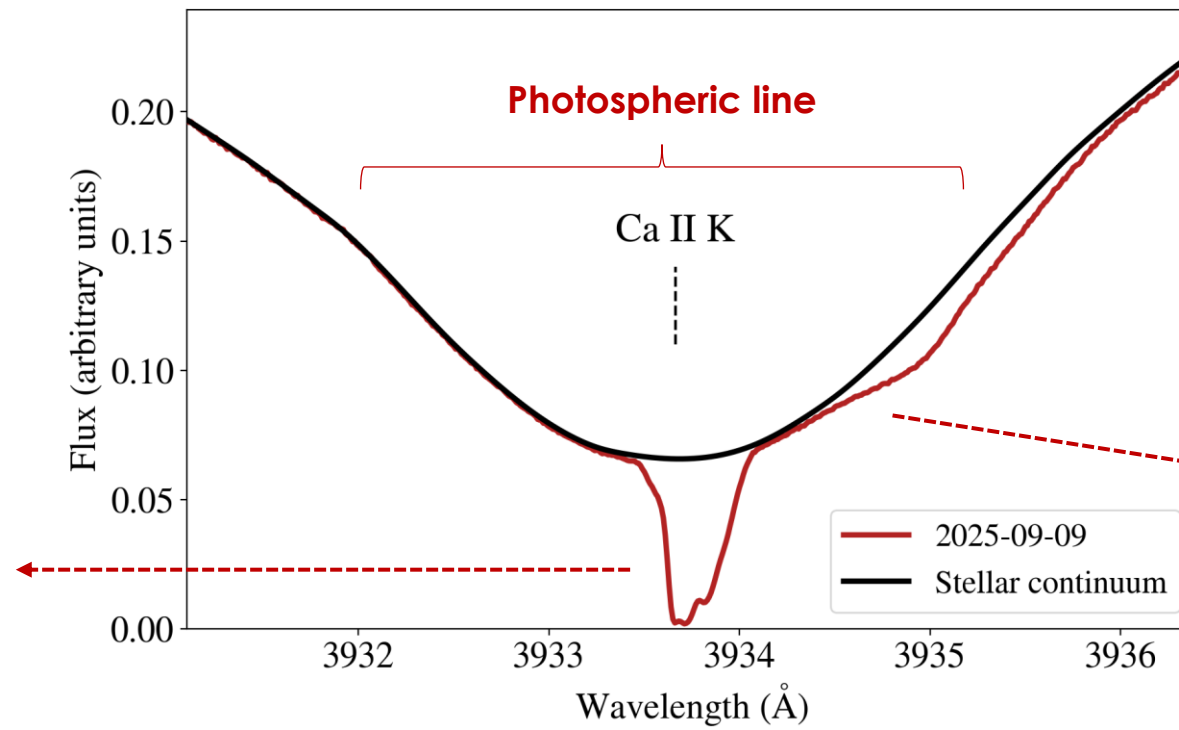
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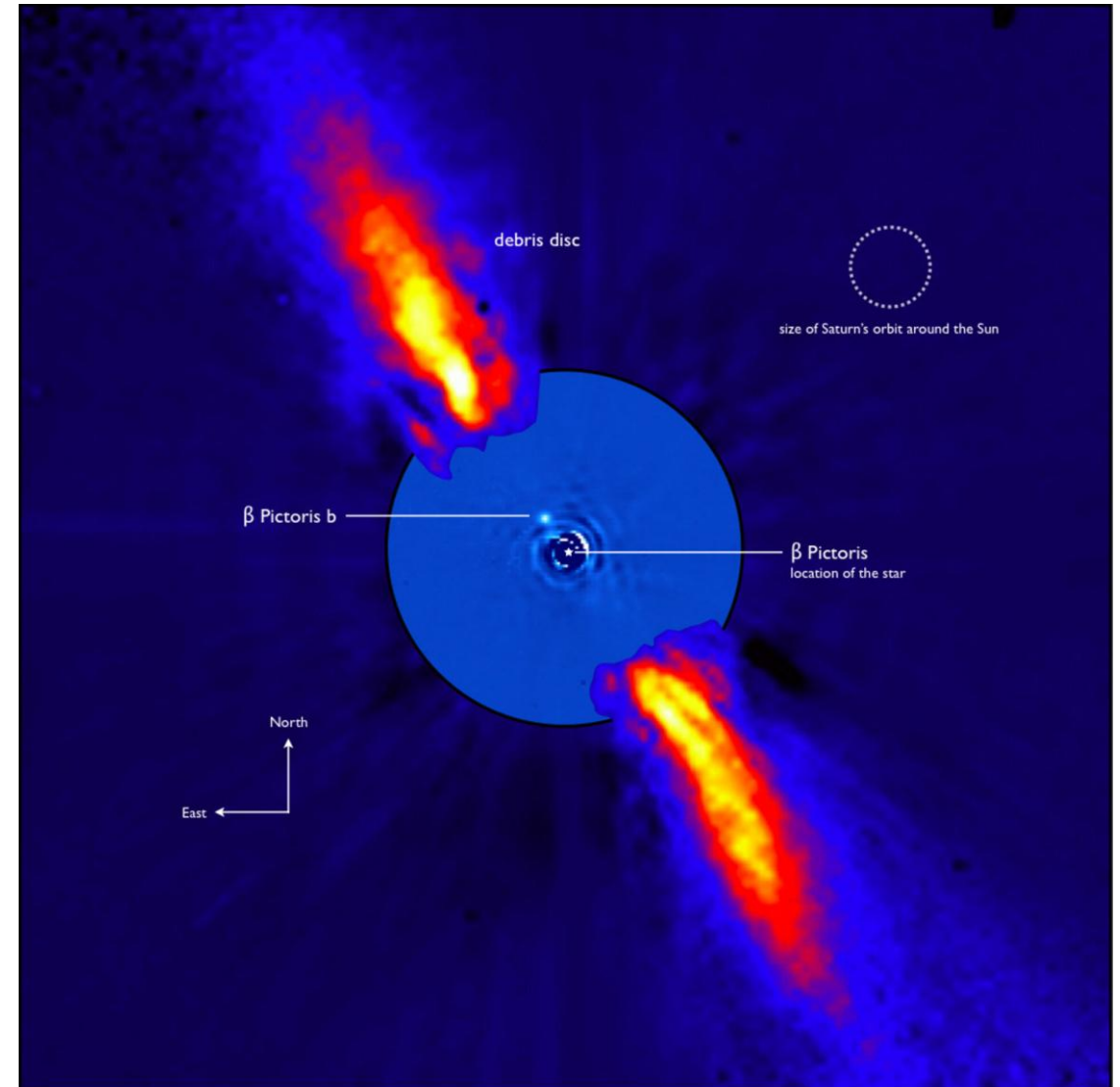
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Introduction

Open questions:

- **What are exocomets?:**
 - *Composition (dusty/icy)?*
 - *Formation place?*
 - *Similarity with solar comets/Asteroids?*
- **How do they interact with planets and discs?**
 - *Contribution to volatile delivery?*
 - *Disc replenishment?*

ESO, Lagrange+ 2009-2010



II. Measuring exocomet C/Fe ratios with HST

➤ **Vrignaud & Lecavelier 2026**

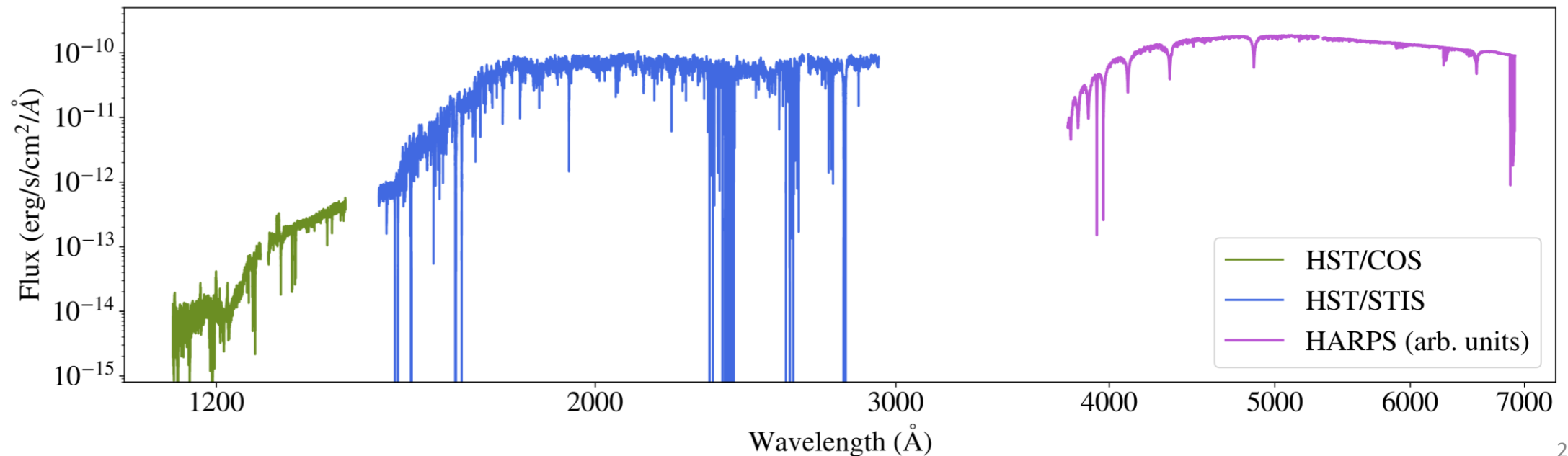
New HST observations

Despite 40 years of observations, the composition of Beta Pic exocomets was still unknown...

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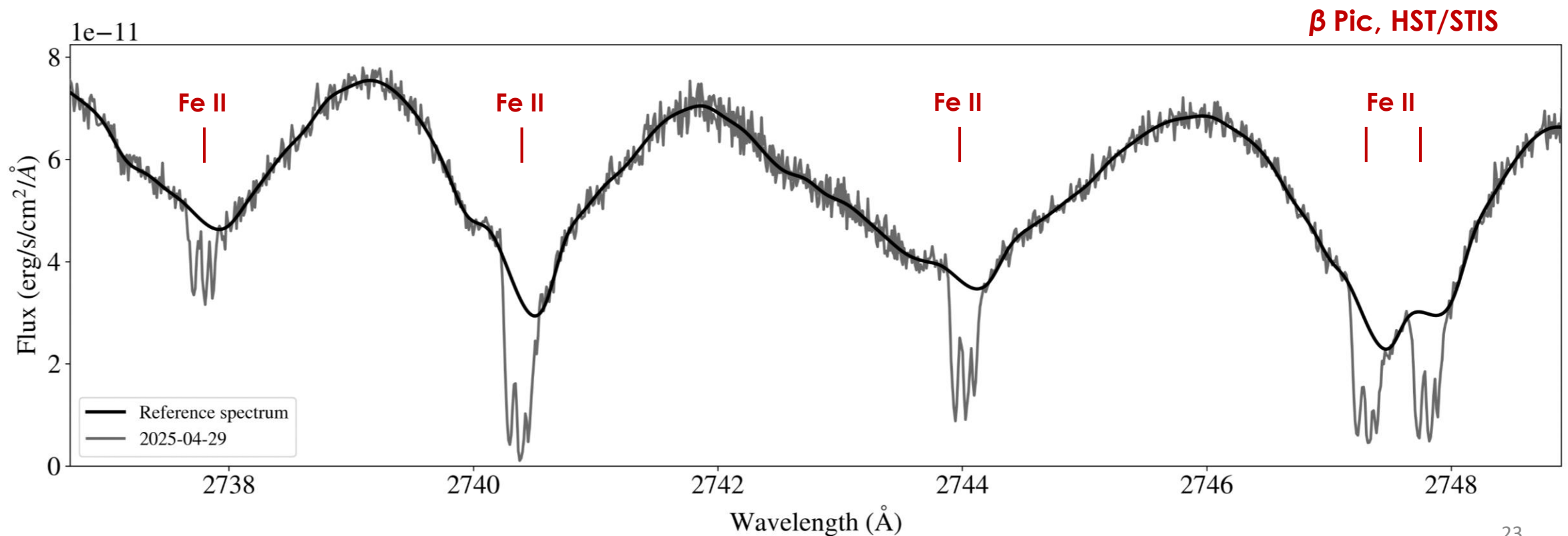
- New HST program to **characterize the composition (C/Fe) and physics of exocomets around Beta Pic** (GO 17790, PI. T. Vrignaud):
- **4 high-resolution spectra obtained in 2025.** Large wavelength coverage: Fe II, Ni II, Ca II, C I...



New HST observations

View of the first spectrum (April 29, 2025)

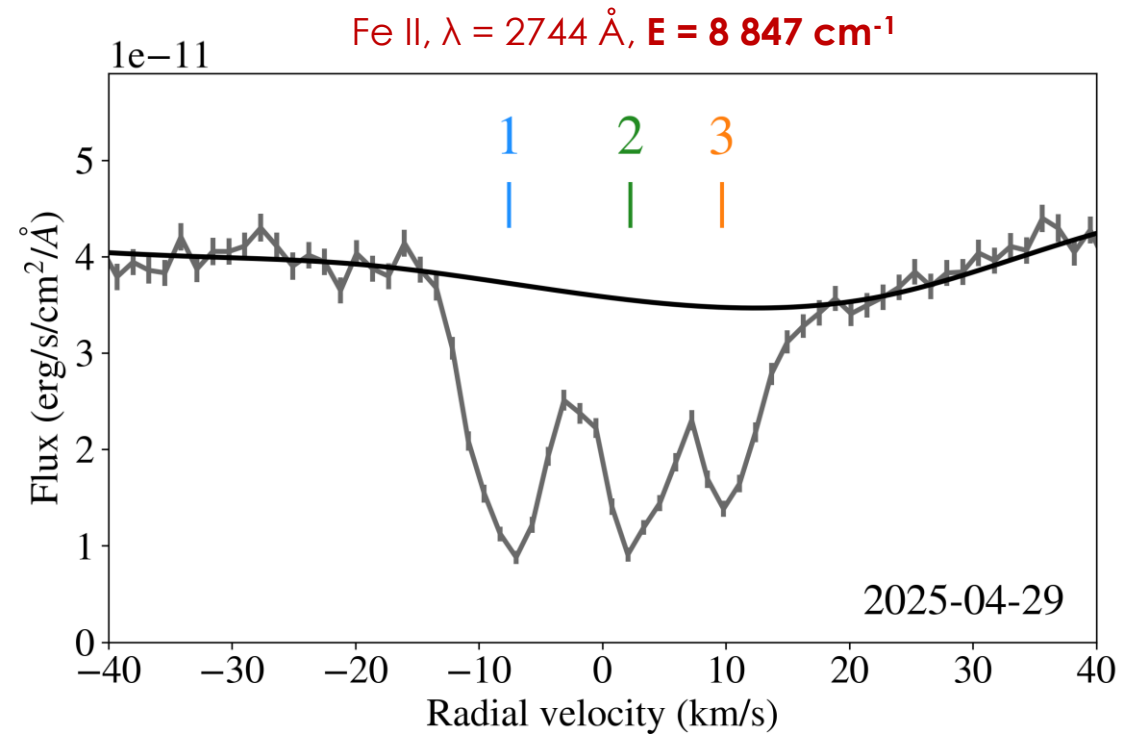
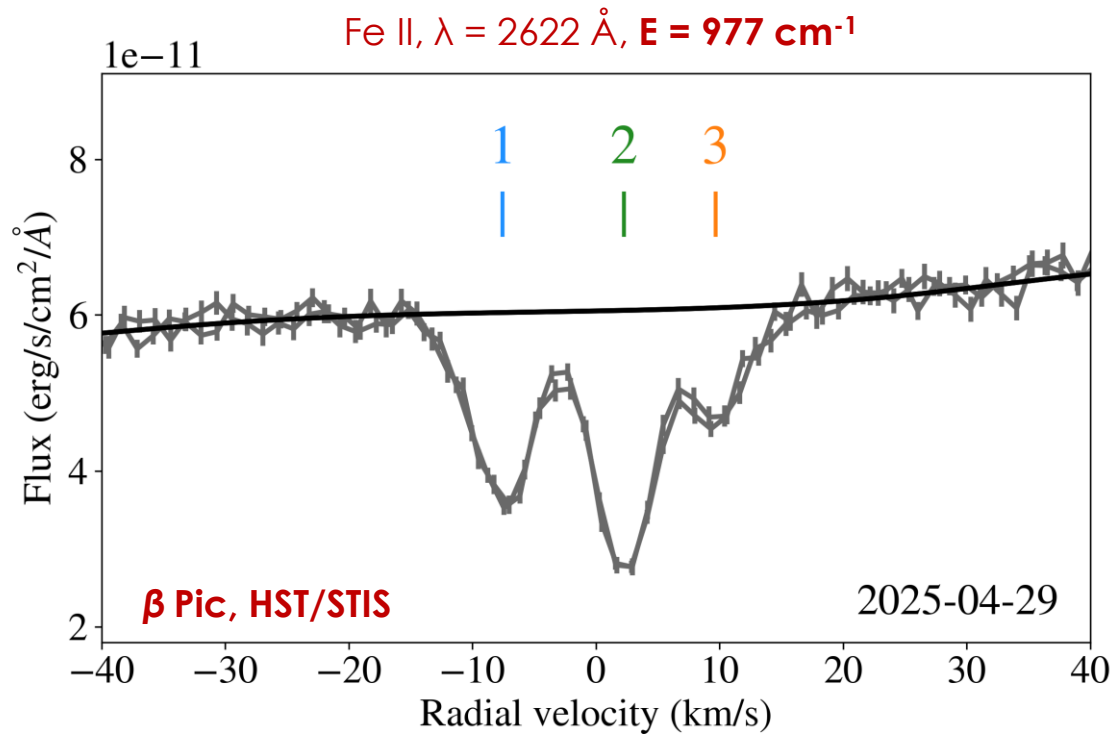
- Observation of **3 transiting exocomets**;
- **We detect the comet signatures in many lines: Fe II, Ni II, S I, C I ...**



New HST observations

View of the first spectrum (April 29, 2025)

➤ The three exocomets exhibit **different excitation states**:

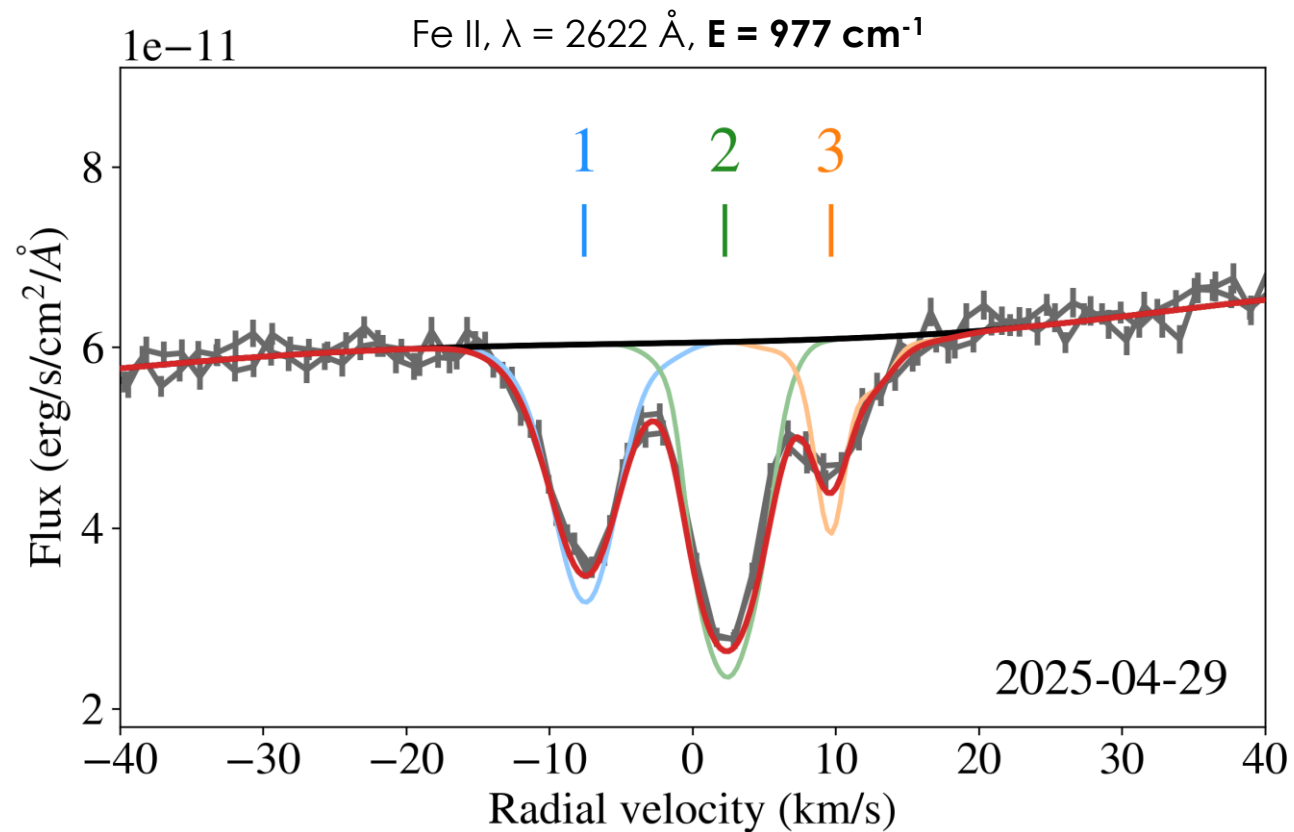


➡ They are located at **different distances from β Pic!** (cf. Vrignaud & Lecavelier 2025)

New HST observations

Measuring transit distances (Vignaud & Lecavelier 2026)

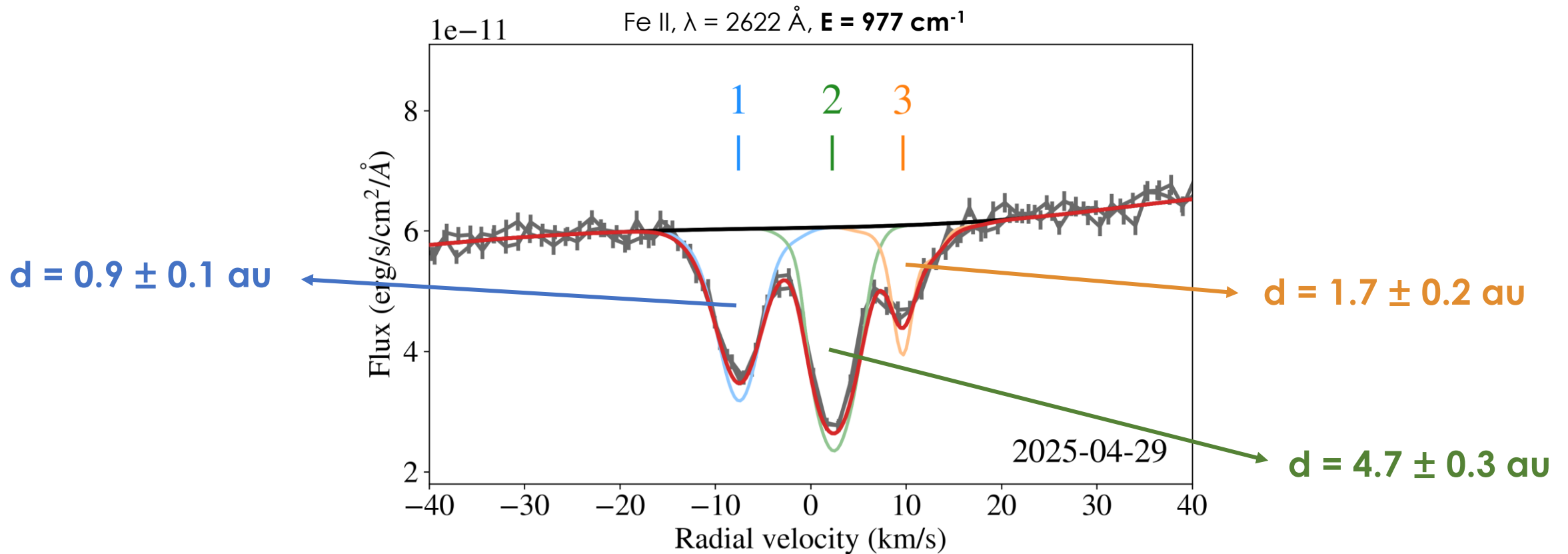
The **transit distances** of the three comets are inferred from their **excitation states**:



New HST observations

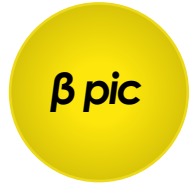
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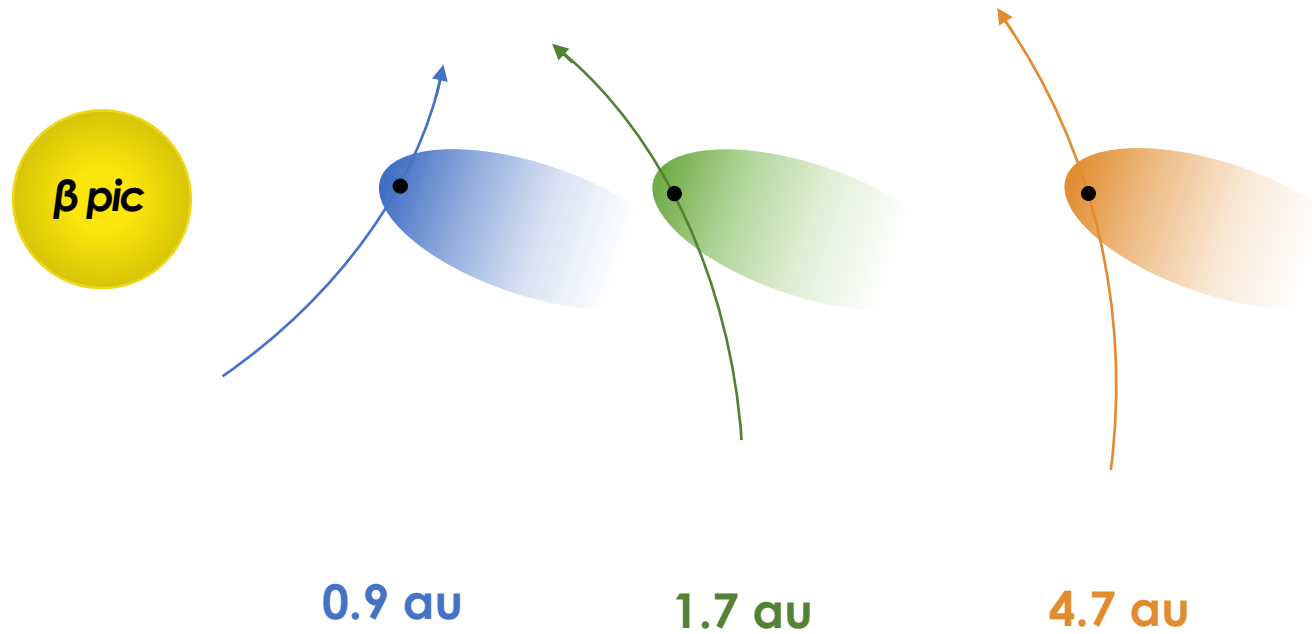
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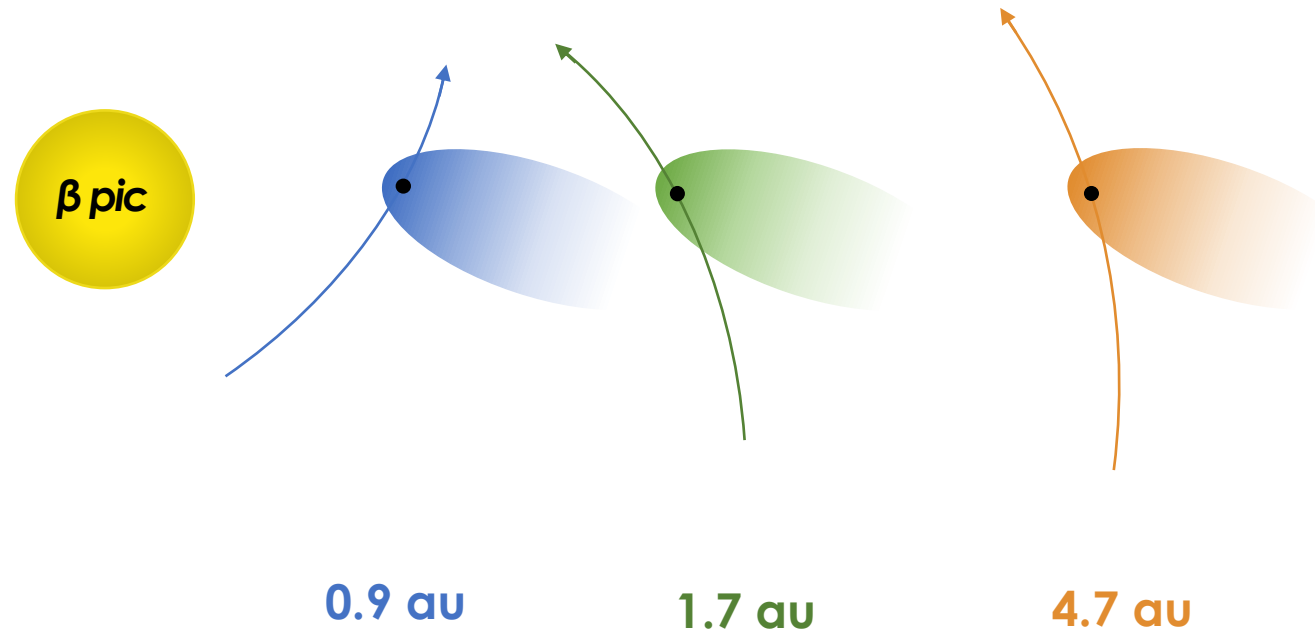
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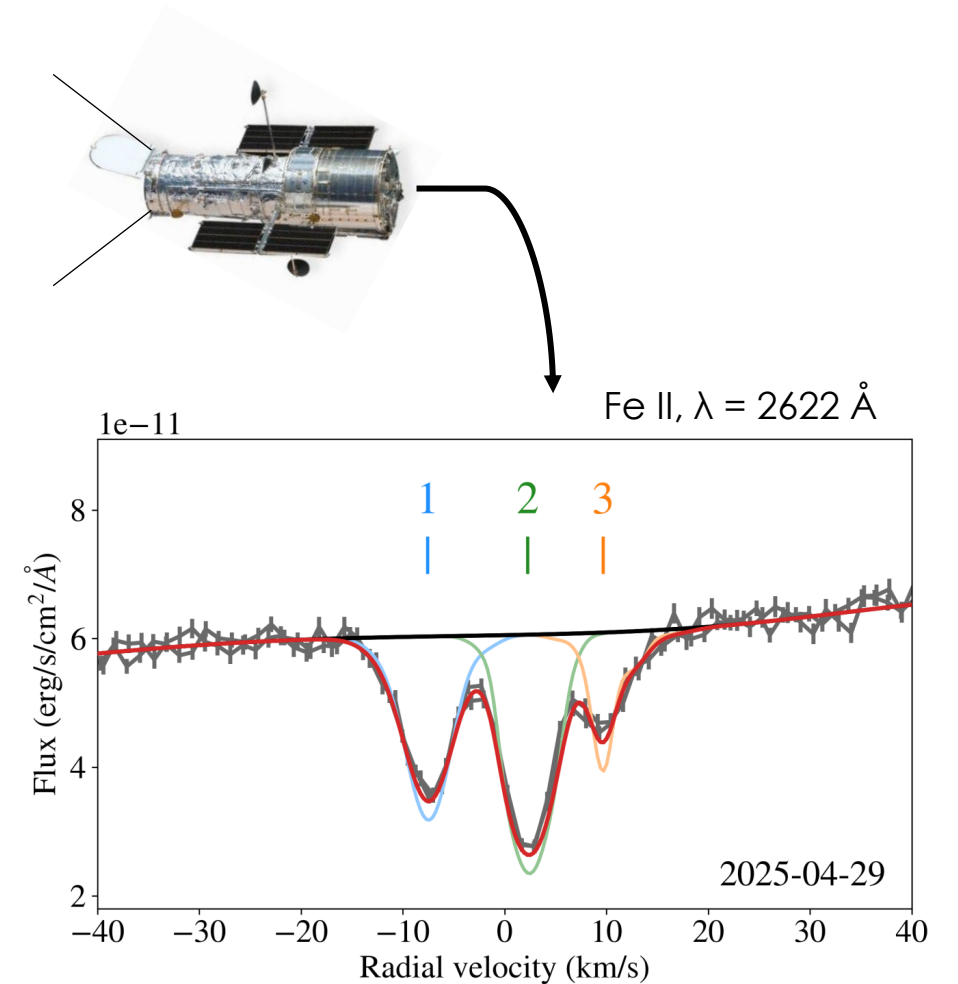
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Big question here:

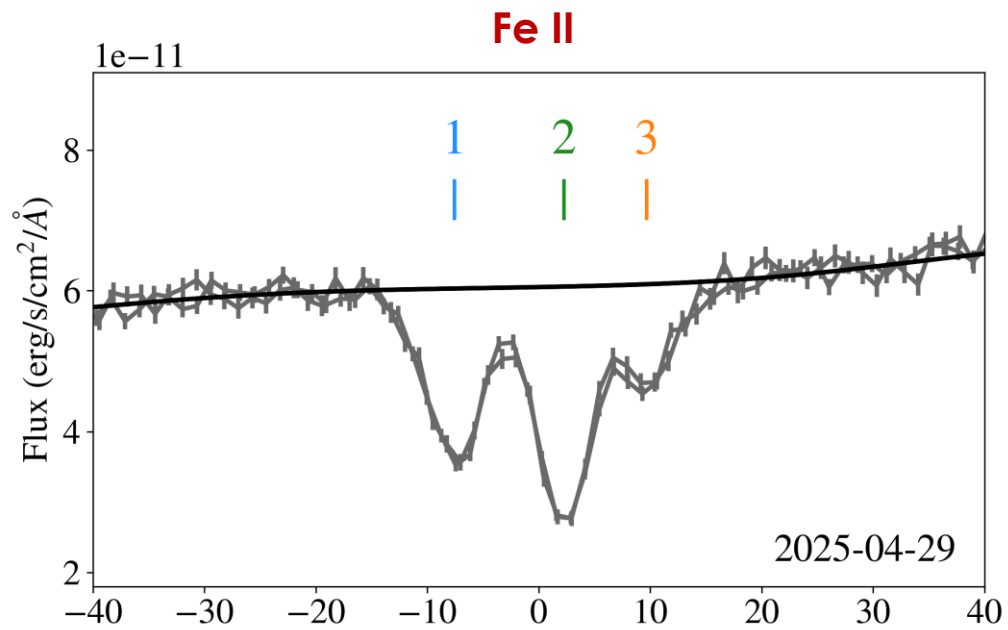
Why do we observe these tails so far from the star?



New HST observations

Measuring C/Fe ratios

The exocomet's signatures are detected in **Fe II lines**...

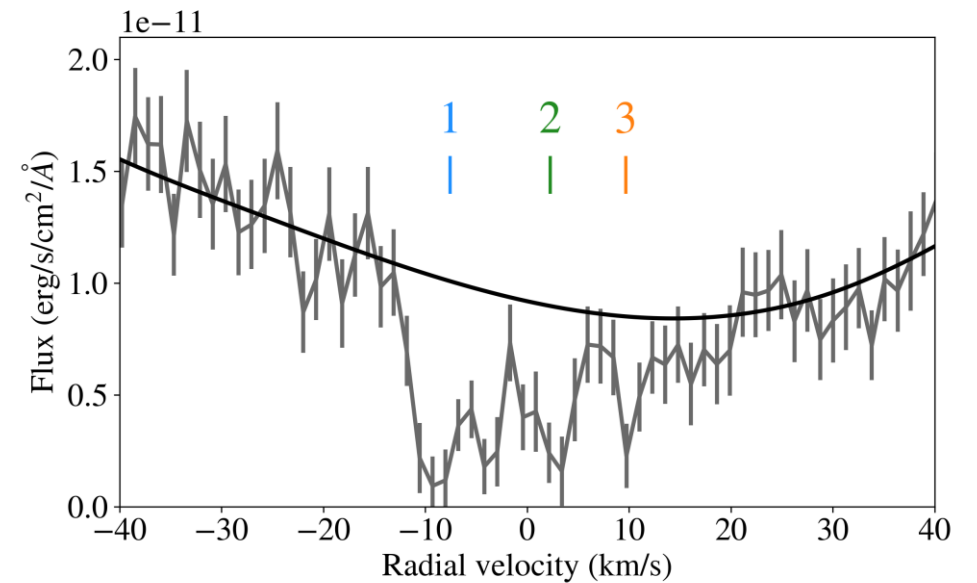
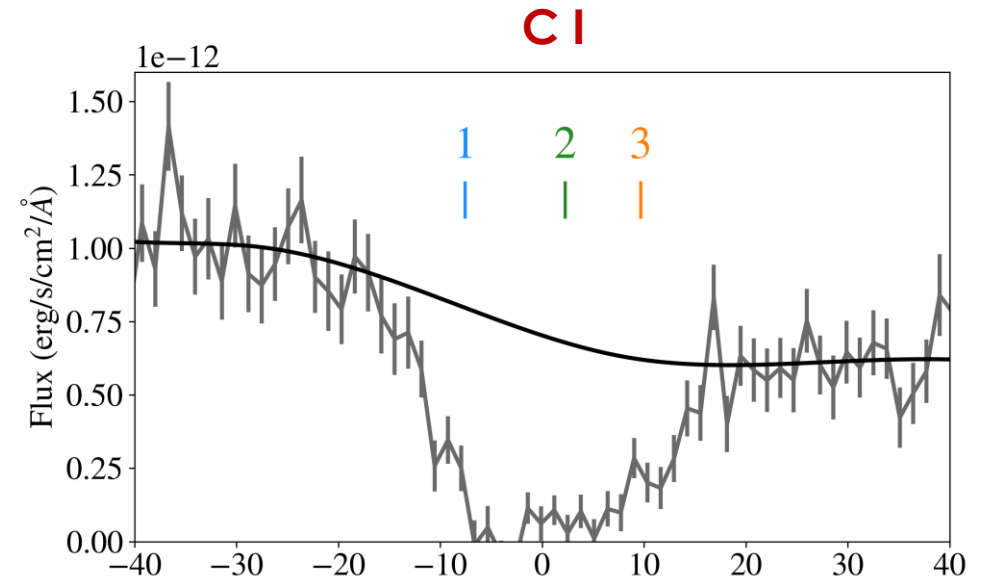
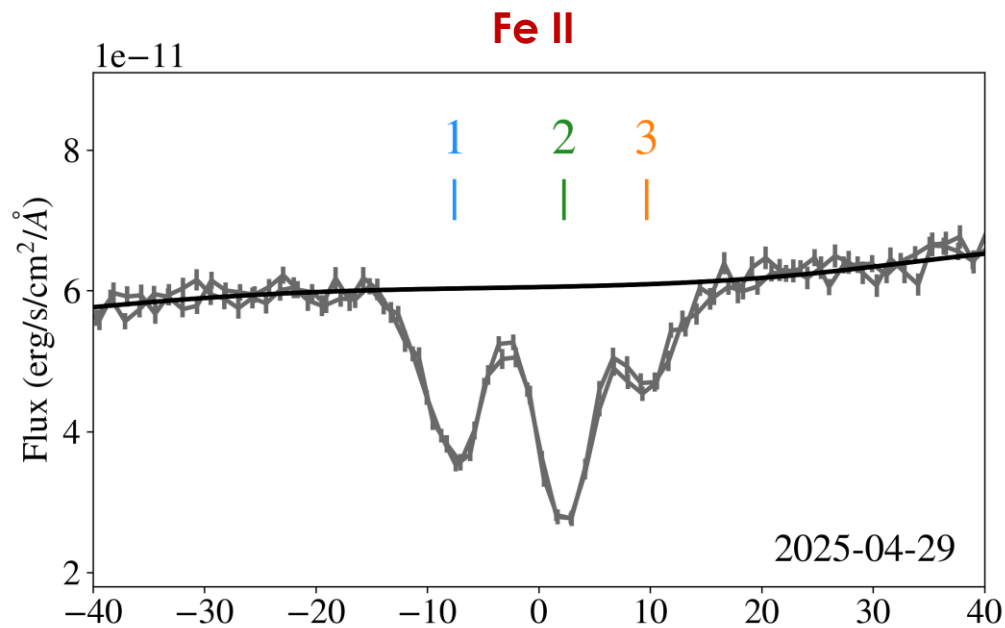


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...but also in **C I**:

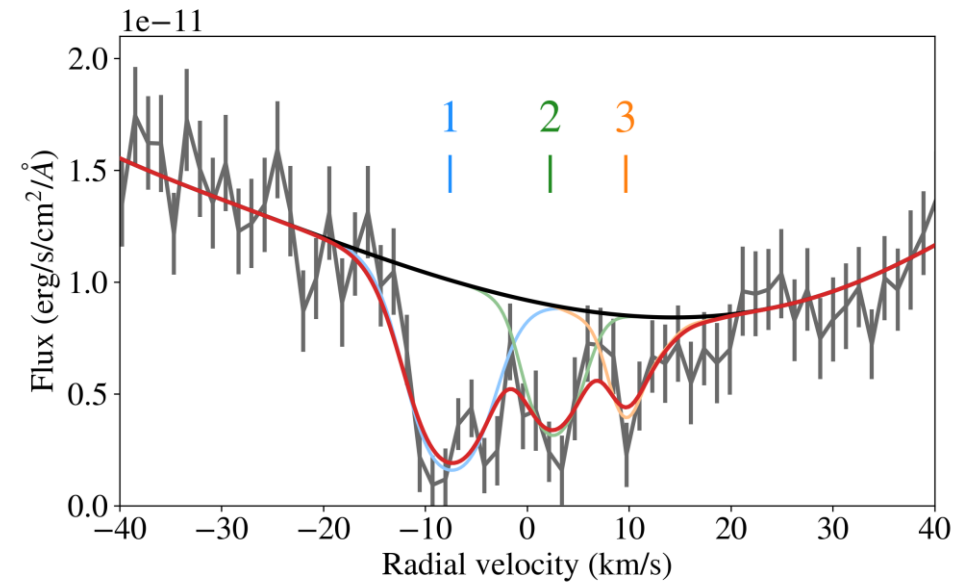
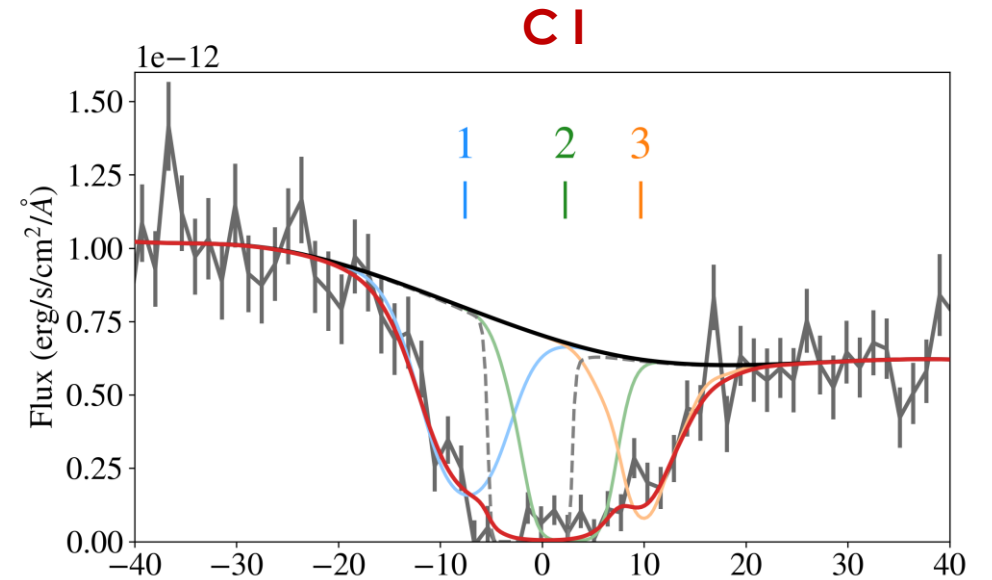
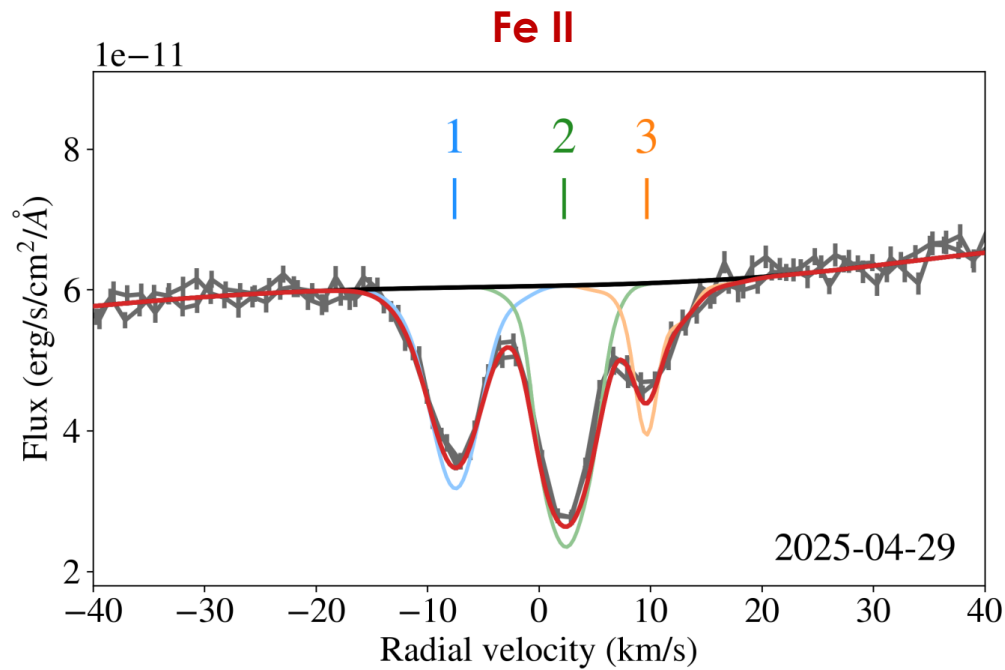


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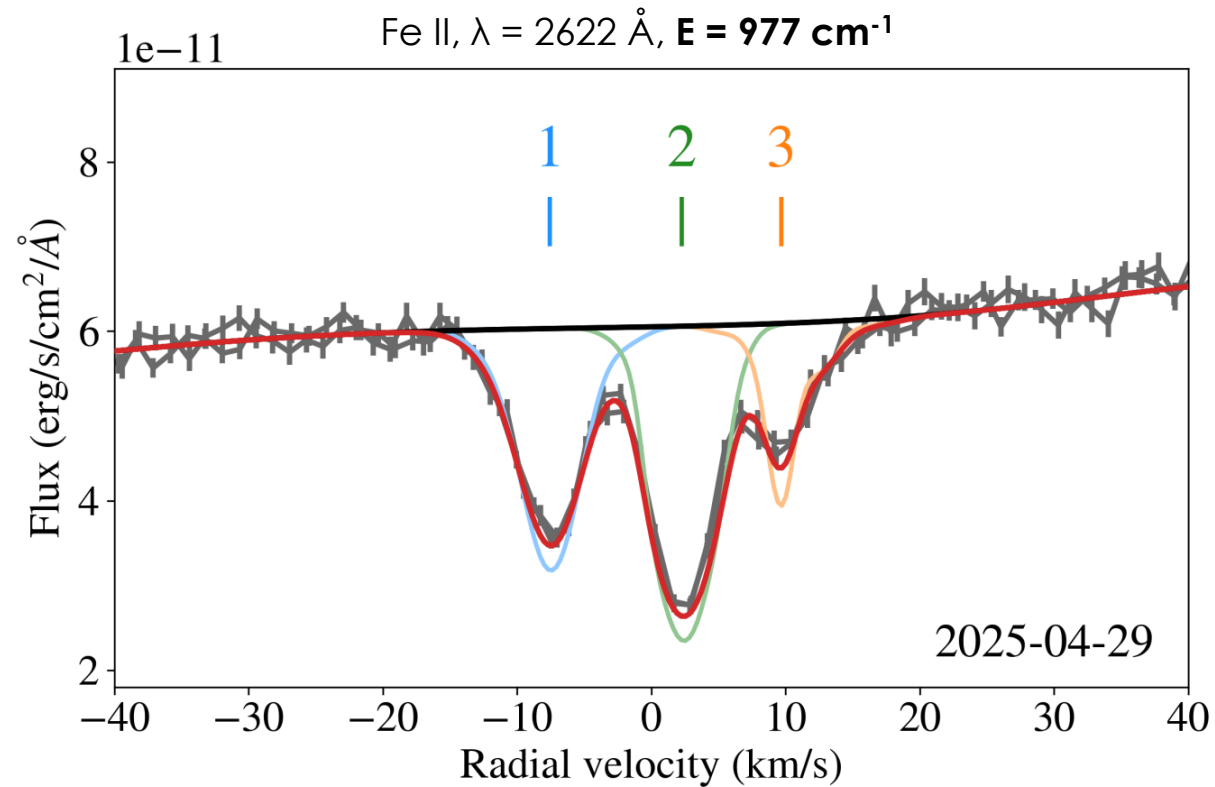
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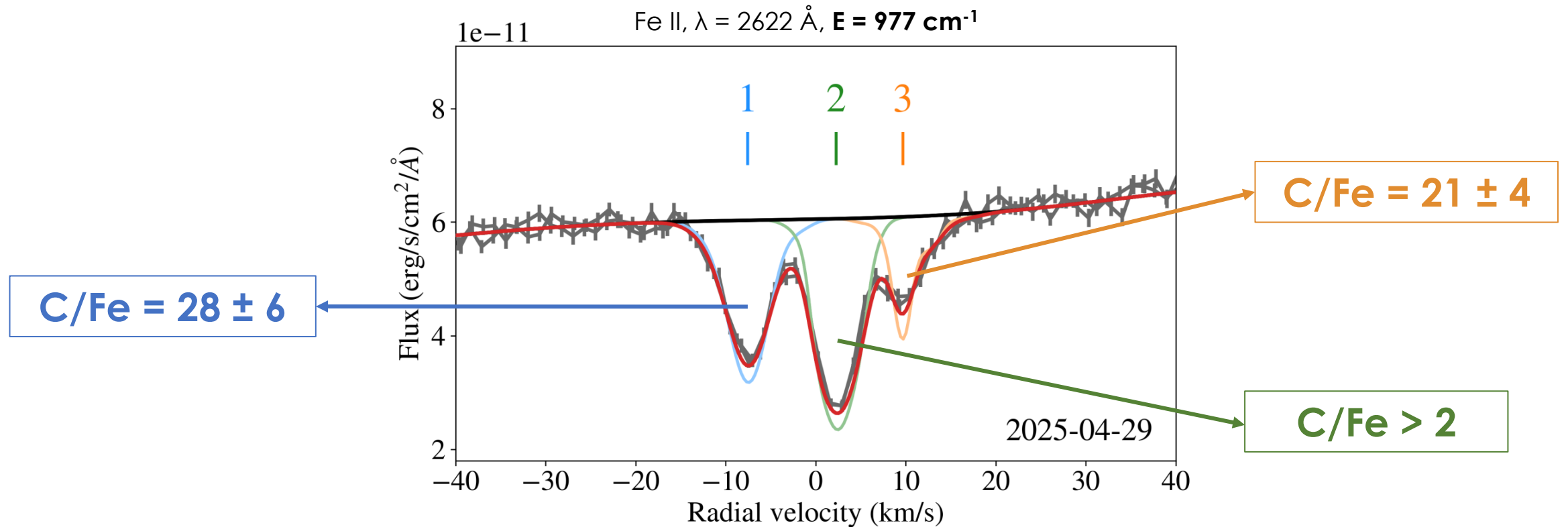
Fitting **Fe II and C I lines** allows to recover the **C/Fe ratios** of the three exocomets:



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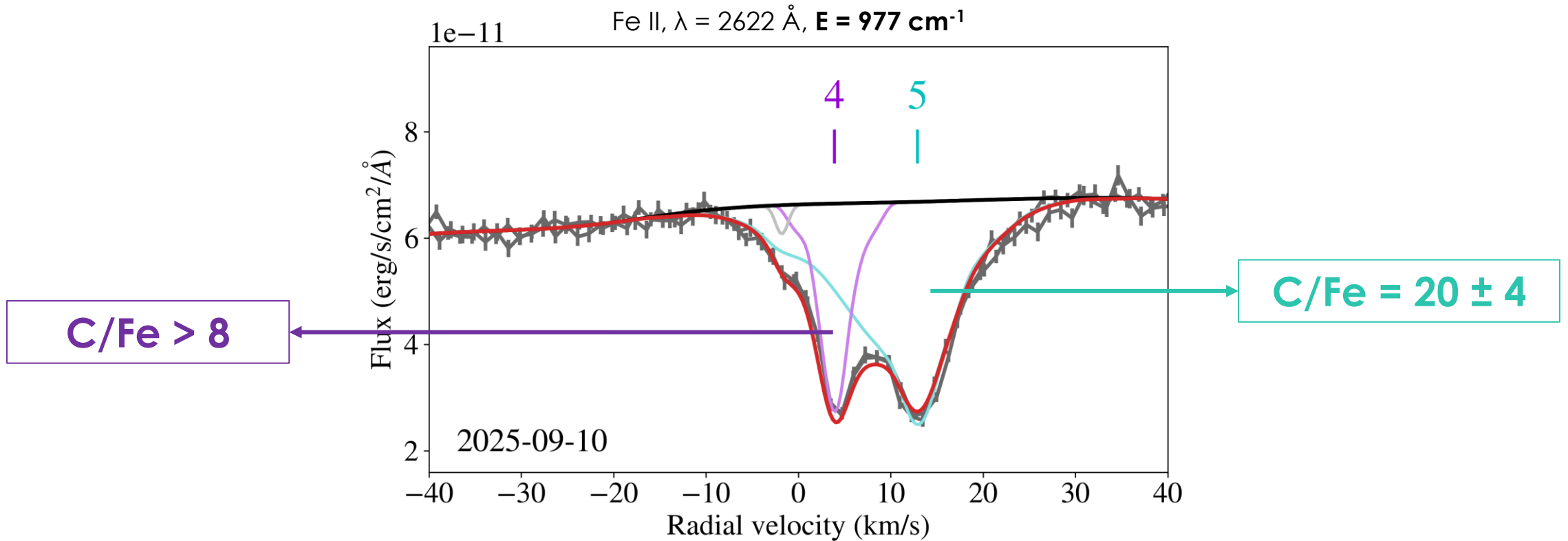


High C/Fe ratios, above the solar value (C/Fe = 10) !

New HST observations

Measuring C/Fe ratios

Observations obtained on **September 10, 2025** provide similar results:

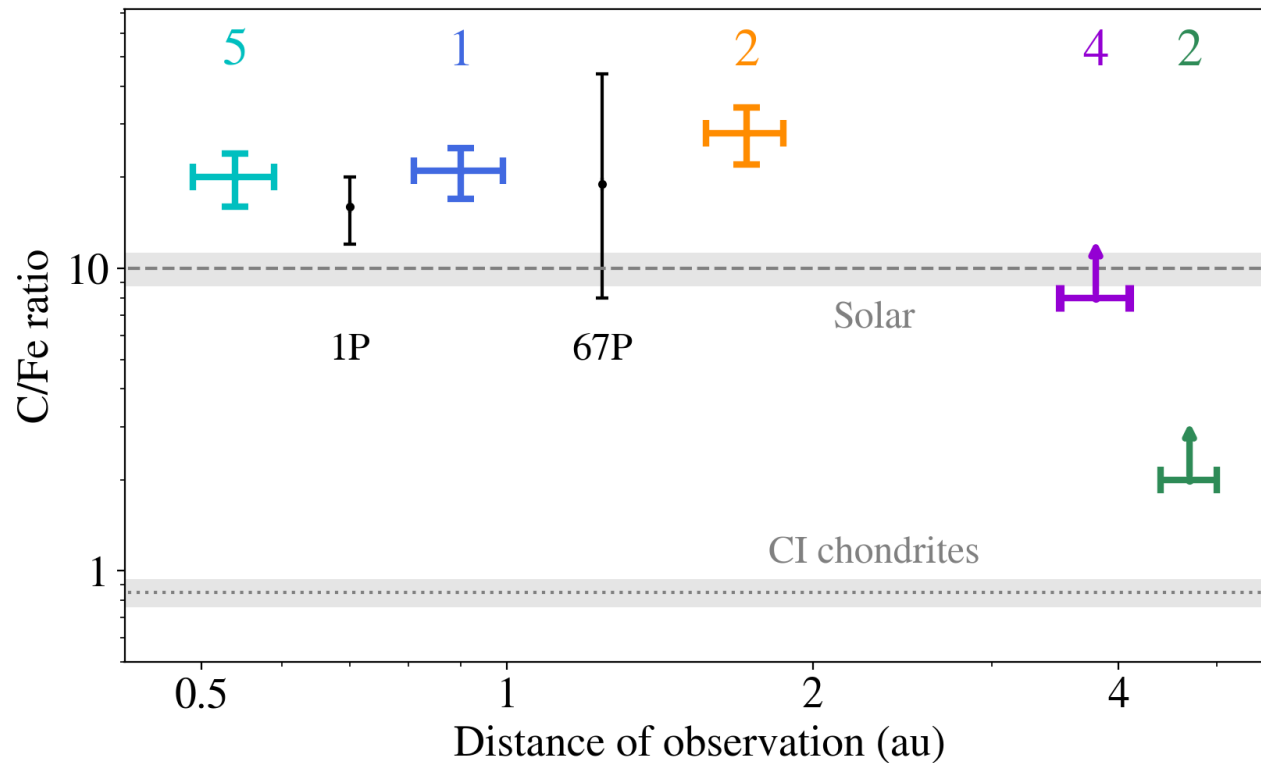


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New HST observations

Measuring C/Fe ratios

C/Fe ratios in **Beta Pic exocomets** are consistent with **Solar System comets** :



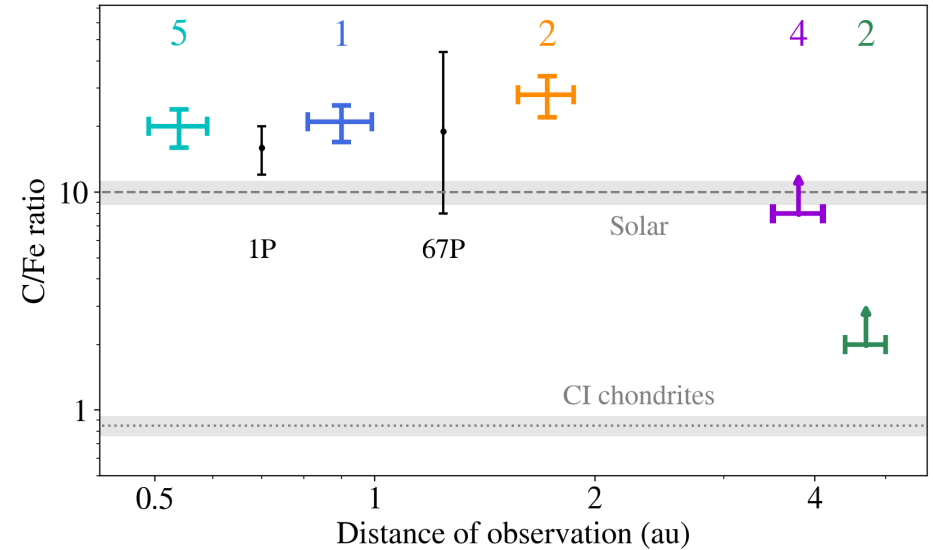
Comets In Beta Pic and in the Solar System share a **common nature**:

- **Carbon-rich** bodies;
- Formed far **from their host star** and **scattered inward through gravitational interactions.**

Conclusion

First **composition measurements** in **small bodies outside the solar system**;

Hint of **ongoing volatile redistribution** driven by exocomets around Beta Pic.



Future prospects:

- Develop **consistent models for the evolution of exocometary systems** (e.g. Beta Pic, HD172555, 49 Cet...)
- The **PLATO mission** will have a huge impact!

