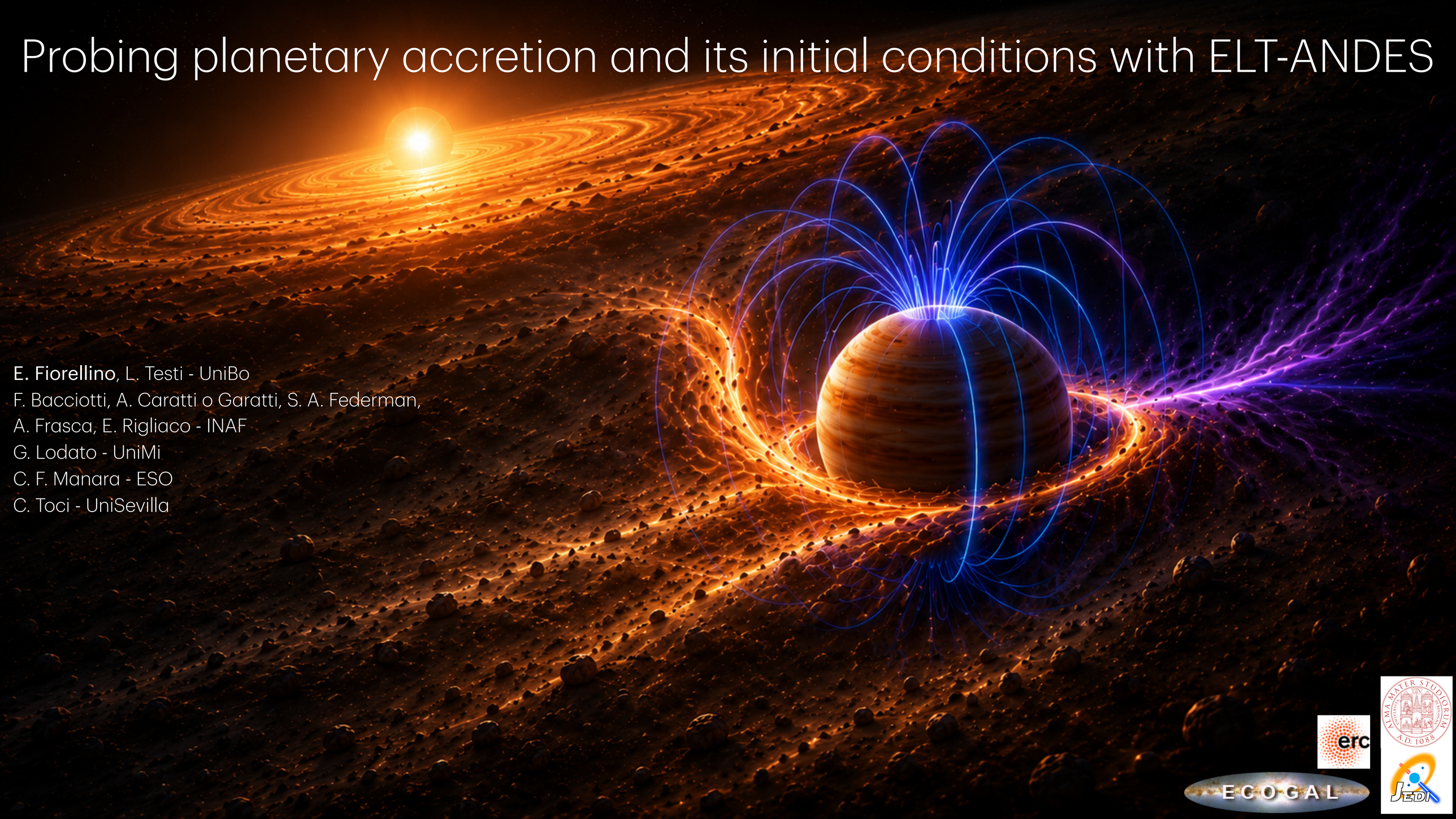
Probing planetary accretion and its initial conditions with ELT-ANDES



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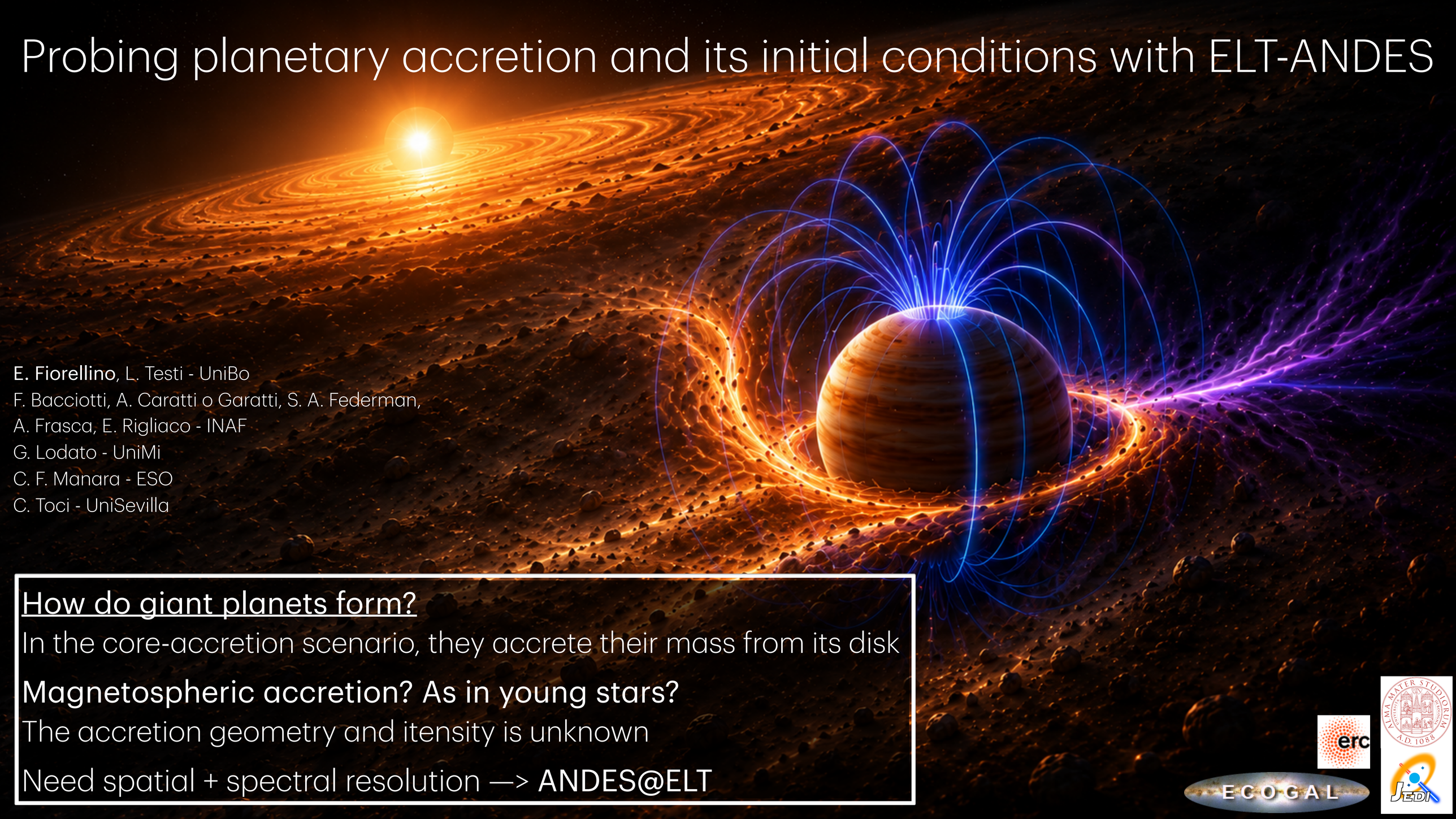

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<u>How do giant planets form?</u>

In the core-accretion scenario, they accrete their mass from its disk

Magnetospheric accretion? As in young stars?

The accretion geometry and itensity is unknown

Need spatial + spectral resolution —> ANDES@ELT

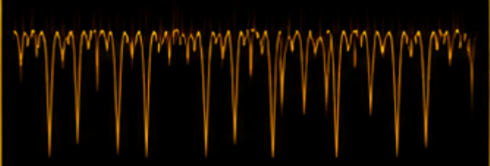
ECOGAL

FROM OBSERVATIONS TO PHYSICAL INSIGHT

MAGNETIC DIAGNOSTICS

1. OBSERVE

FeH molecular line forest
with ANDES / ELT

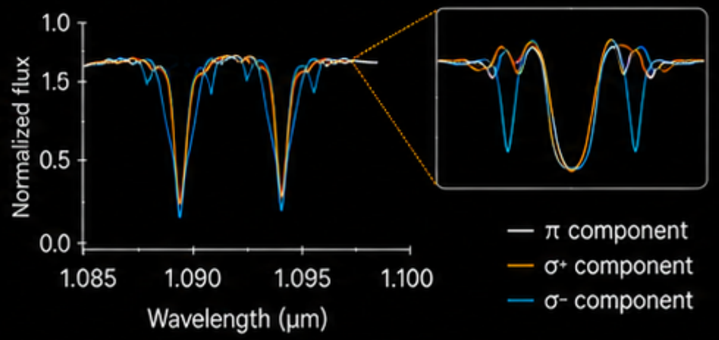


FeH

R ~ 100,000 | High S/N

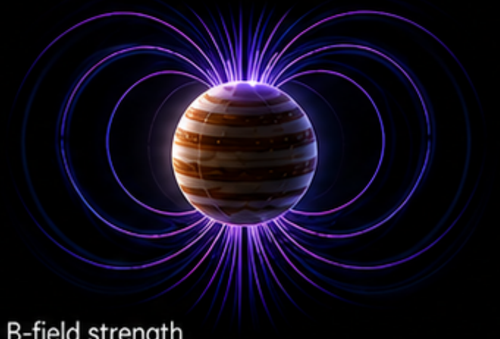
2. DETECT ZEEMAN SIGNATURES

in FeH absorption lines



3. MEASURE MAGNETIC FIELD

via Zeeman splitting



B-field strength

MAGNETIC FIELDS MEASURED

- Field strength
- Test of magnetospheric accretion

FROM OBSERVATIONS TO PHYSICAL INSIGHT

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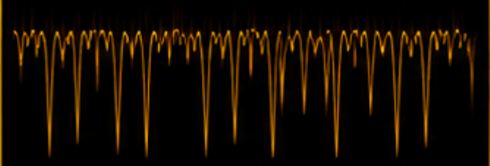

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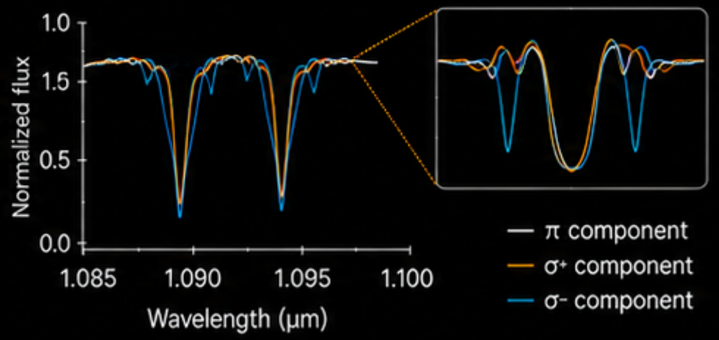

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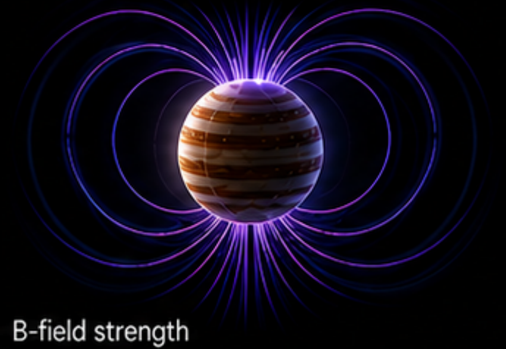

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ACCRETION DIAGNOSTICS

1. OBSERVE
Accretion tracers
Hα, Paβ, Brγ

R ~ 100,000 | Spatial res. ~ 1–10 au

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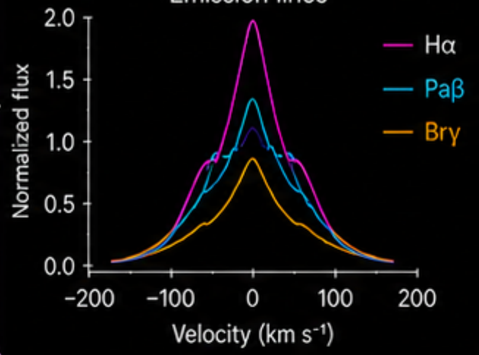
Emission lines



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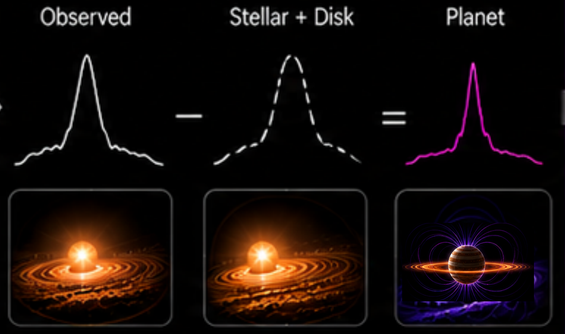
Remove stellar & disk contribution



4. ACCRETION FLOW DIAGNOSTICS
Constrain geometry, rate and physical structure

ACCRETION CHARACTERIZED
- Accretion rate
- Flow geometry
- Kinematics
- Physical conditions

FROM OBSERVATIONS TO PHYSICAL INSIGHT

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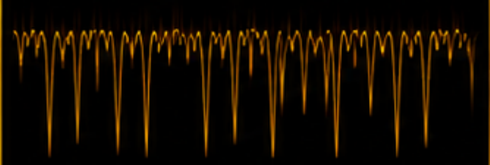

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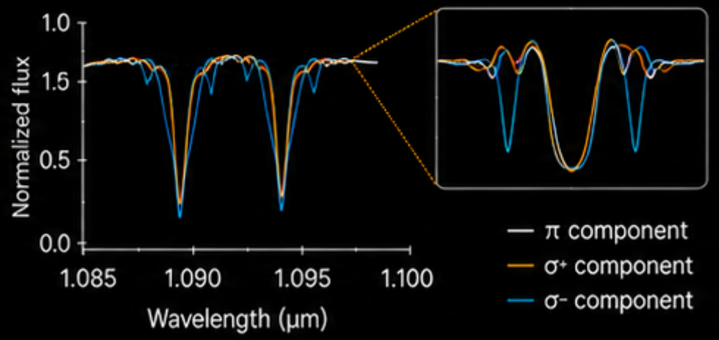

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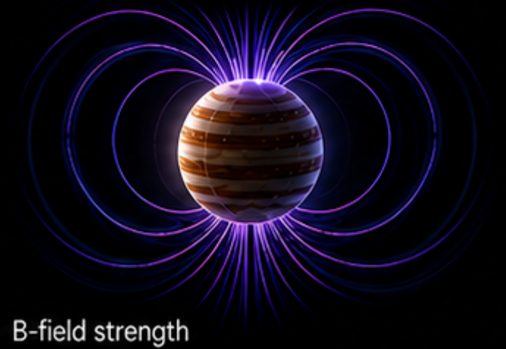

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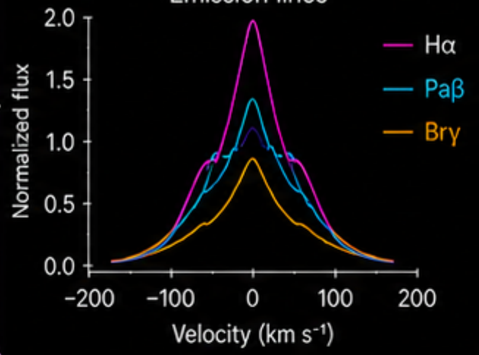

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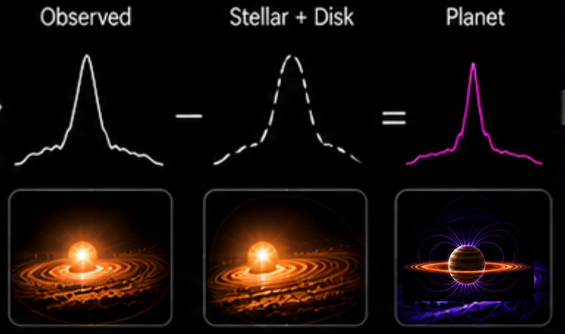

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COMBINING MAGNETIC AND ACCRETION DIAGNOSTICS → Test magnetospheric accretion and determine planet initial conditions (hot vs cold start)

MAGNETIC FIELDS OF FORMING PLANETS

Probing magnetospheric accretion and planetary growth with ELT and ANDES

If planetary magnetic fields are strong enough, accretion can occur through MAGNETOSPHERIC ACCRETION, as in young stars. This enables us to study how giant planets grow and how magnetic fields regulate accretion.

1 GAS AND DUST DISK
Material in the protoplanetary disk feeds the forming planet.

2 ACCRETION FLOWS
Gas streams along magnetic field lines from the disk onto the planet.

3 PLANETARY MAGNETIC FIELD
The planet generates a magnetic field that truncates the disk, channels accretion along field lines and drives outflows.

4 OUTFLOWS & WINDS
Magnetically driven winds remove angular momentum and regulate planetary growth and disk evolution.

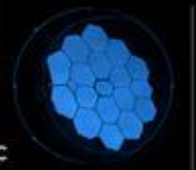
Why magnetic fields matter

- Accretion and jets
- Stellar activity
- Angular momentum transport
- Plasma dynamics

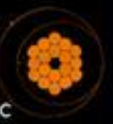
ANGULAR RESOLUTION: ELT vs VLT

Thanks to its 39 m aperture, ELT achieves unprecedented angular resolution in the near-IR, enabling the direct study of forming planets and their magnetospheres.

ELT (39 m)
at 2 μm (K band)
~ 10 mas
= 1 au at 100 pc



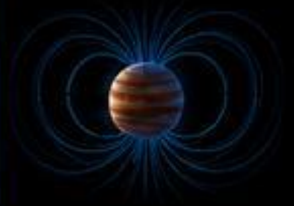
VLT (8 m)
at 2 μm (K band)
~ 30–50 mas
= 3–5 au at 100 pc



ELT CAN RESOLVE CIRCUMPLANETARY ENVIRONMENTS AND MAGNETIC FIELDS AT SCALES OF ~1 AU (100 PC)

VLT CANNOT SEPARATE THE PLANET FROM ITS DISK AND CANNOT PROBE THE MAGNETOSPHERE

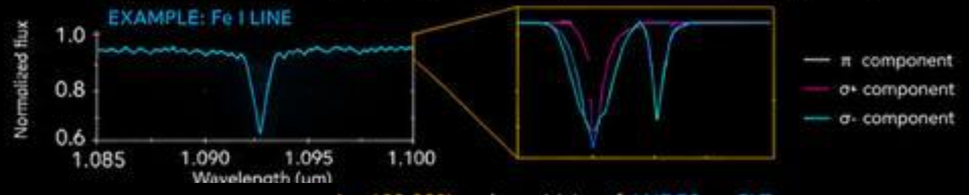
MAGNETIC FIELD LINES



Planetary magnetic fields connect the planet and the disk. These fields can be detected through Zeeman signatures in atomic lines (e.g., Fe I, Fe II).

DETECTING PLANETARY MAGNETIC FIELDS WITH ELT AND ANDES

Zeeman signatures in atomic lines (e.g., Fe I) reveal the magnetic field strength and geometry.



High spectral resolution ($R > 100,000$) and sensitivity of ANDES on ELT enable the detection of Zeeman splitting at the sub-Gauss level.

ANDES + ELT CAPABILITIES

- High spectral resolution (R > 100,000)
- Extreme sensitivity (down to sub-Gauss levels)
- Direct detection of magnetic fields in forming planets

OPENING A NEW WINDOW ON PLANET FORMATION

KEY NUMBERS

ELT angular resolution (2 μm):
~10 mas ~1 au at 100 pc

VLT resolution (2 μm):
~30–50 mas ~3–5 au at 100 pc

ELT diameter: 39 m

VLT diameter: 8 m

Principal Investigator
E. Fiorellino
University of Bologna, INAF Trieste

Co-Investigators:
L. Testi, Univ. | F. Bacciotti, INAF Firenze | A. Caratti o Garatti, INAF Napoli | S. A. Federman, INAF Napoli | A. Frasca, INAF Catania | G. Lodato, University Milan | C. F. Manara, ESO | E. Rigliaco, INAF Padova | C. Toci, INAF Firenze

By measuring magnetic fields in forming giant planets for the first time, we will test magnetospheric accretion in planetary systems and uncover how magnetic fields regulate accretion, outflows and the growth of planets.