Characterizing the First Field Brown Dwarf Binary Discovered with Euclid

Brown Dwarfs Keep Their Cool: 30 years of Substellar Science

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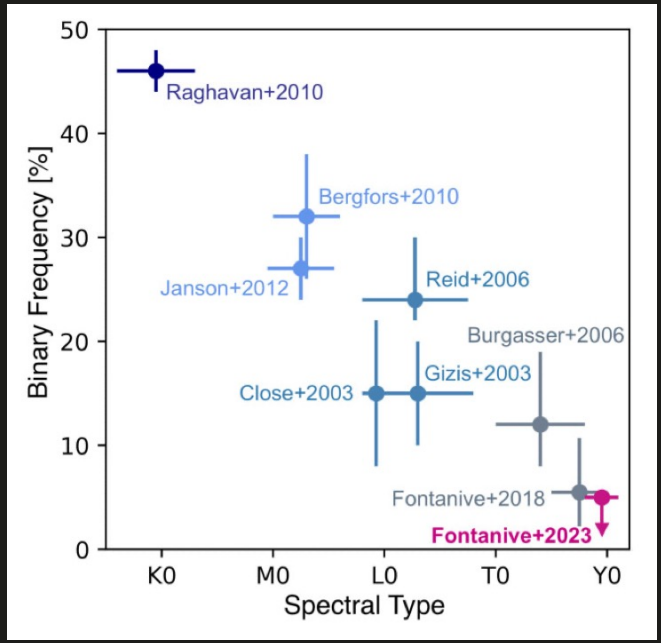
Brown Dwarfs
in binary systems

➔ Field BDs binary fraction: ~ 5% - 25%

➔ Multiplicity may be higher in the L/T transition



C. Fontanive et al. (2023)

Brown Dwarfs
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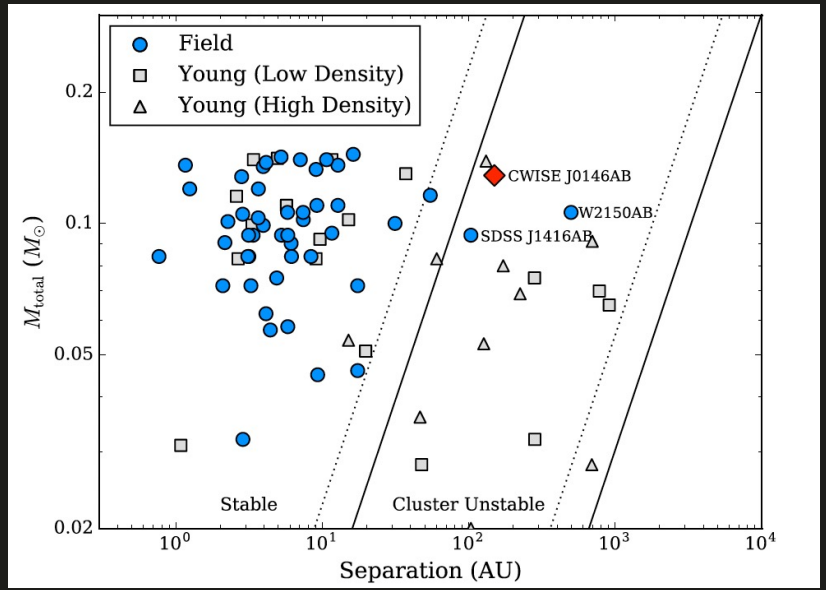
➔ Field BDs binary fraction: ~ 5% - 25%

➔ Multiplicity may be higher in the L/T transition

➔ Median separation ~ 4 AU, very few systems wider than 20 AU

➔ Discover wide field binaries could provide useful insight on formation and evolution of BDs



Softich, E., et al. (2022)

Our Study

From Peculiar Spectrum to Binary System

Peculiar spectrum UCD identified

Revealed as a binary in Euclid images

Analysis and characterization using Euclid data

Follow-up observations with EMIR at GTC

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Images & Catalogue – Euclid VIS+NISP instruments

Euclid Quick Release (Q1) images and catalogue

	Wavelength range	*Pixel Size*
VIS	5500 – 9000 Å	0.1 arcsec
Y	9200 – 11460 Å	0.3 arcsec
J	11460 – 13720 Å	
H	13720 – 20000 Å	

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Data description

Images & Catalogue – Euclid VIS+NISP instruments

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Spectra - target and templates (L4, L7, L9, T0, T1)

Euclid – NISP instrument

Spectral coverage	*Exp. Time*
12000 – 19000 Å	2200 s

GTC – EMIR spectrograph

	Spectral coverage	*Int. Time*	*Exp. Time*	*ABBA throw*
YJ	8900 – 13400 Å	200 s	2400 s	6 arcsec
HK	14500 – 24300 Å	160 s	2560 s	6 arcsec

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Procedure

1. Deblend the objects

2. Astrometry characterization

3. Photometry

4. Infer the best spectral combination

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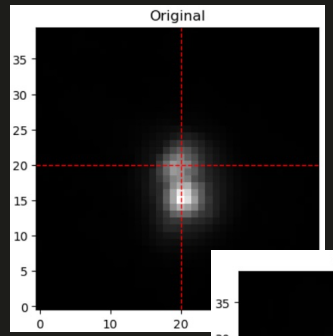
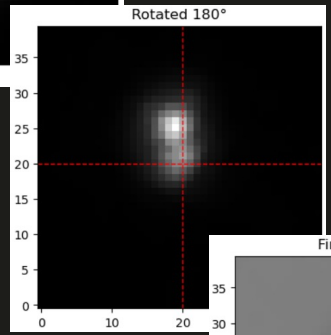
1. Deblend the objects

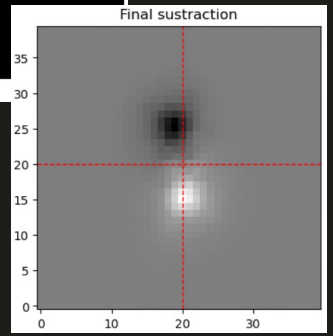
➔ Binary components partially blended

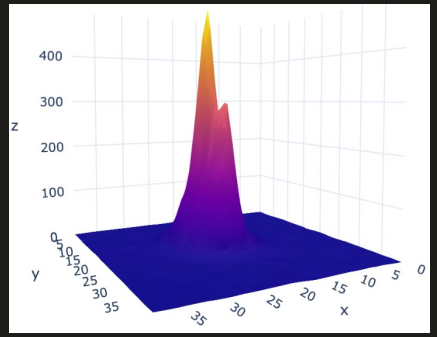
➔ Image rotated + self-subtracted

➔ Centred on secondary to isolate primary flux and vice versa









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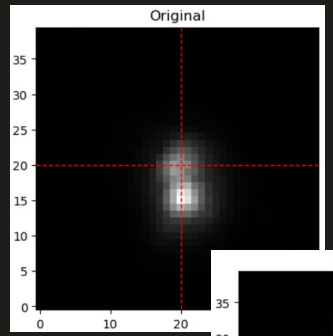

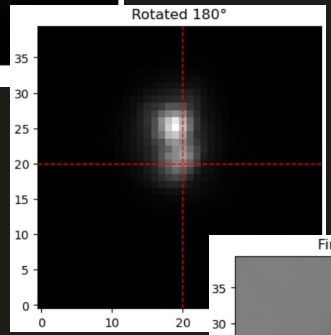

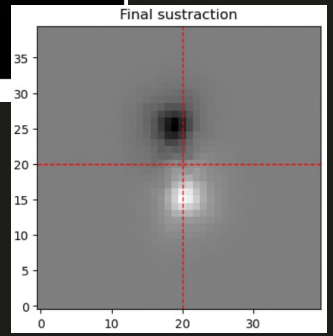

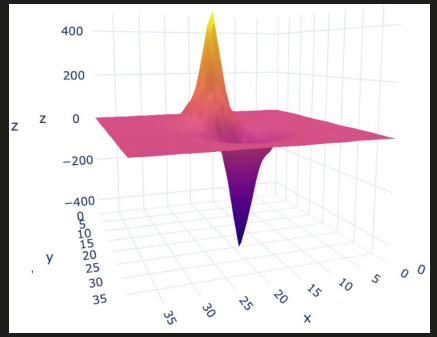

2. Astrometry characterization

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Procedure

1. Deblend the objects

2. Astrometry characterization

➔ **Centroid** determination

➔ Derive **angular separation**, θ

➔ Calculate **physical separation** using a spectrophotometric distance determination

$$s = d\,\theta$$

Sanghi et al. (2024) relations: absolute magnitudes vs SpT

$$M = m + 5 - 5 \cdot \log(d)$$

3. Photometry

4. Infer the best spectral combination

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Procedure

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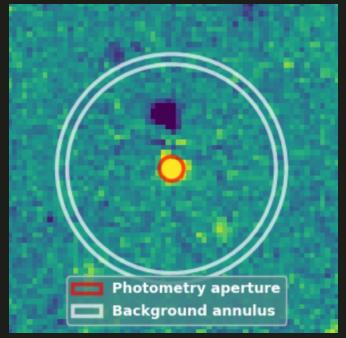
3. Photometry

➔ Euclid catalogue fluxes to AB magnitudes:

$$m_{AB} \approx -2.5\, log_{10}\left(\frac{F_{Jy}}{3630.78\, Jy}\right)$$

➔ Aperture photometry on target and comparison objects



Measured flux vs. catalogue magnitudes relation

4. Infer the best spectral combination

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Procedure

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4. Infer the best spectral combination

➔ Combine template spectra considering flux ratios constrained by Euclid photometry (Y_E, J_E, H_E)

➔ Flux normalized

➔ Spectra comparison: visual, residuals & χ^2

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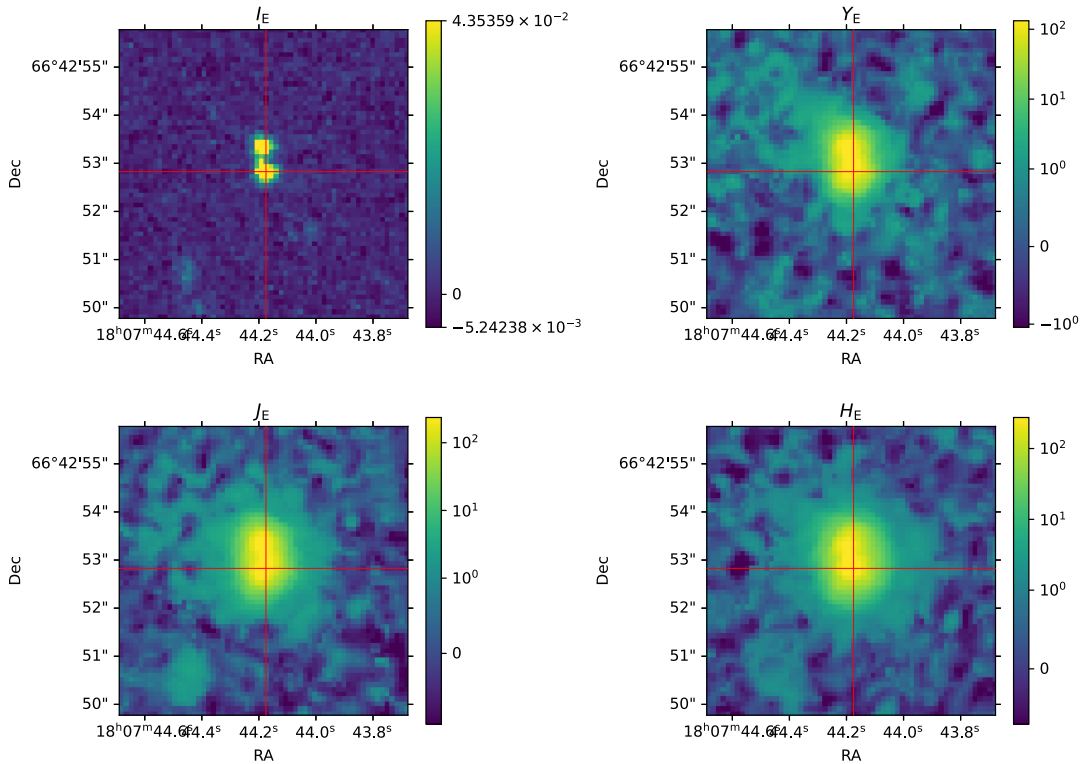
A Euclid spatially resolved binary



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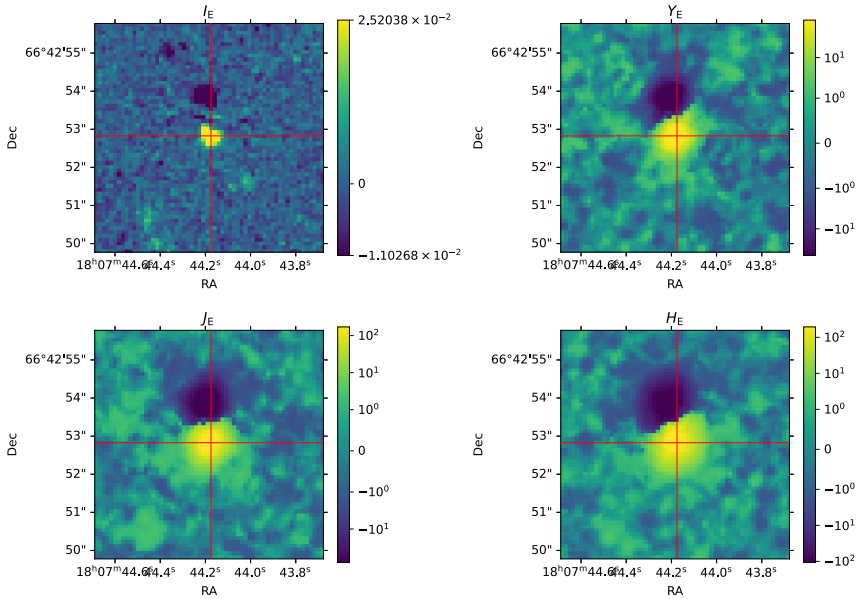
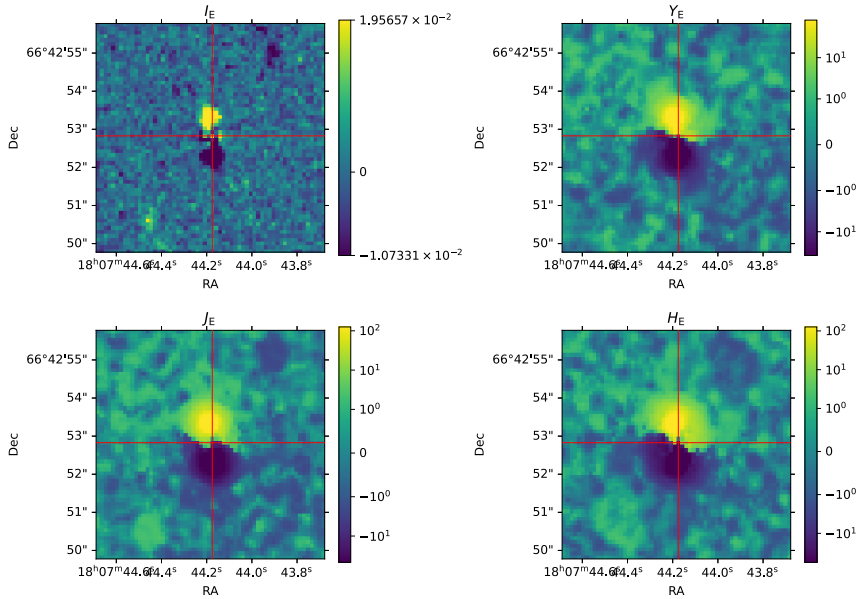
Primary



Secondary



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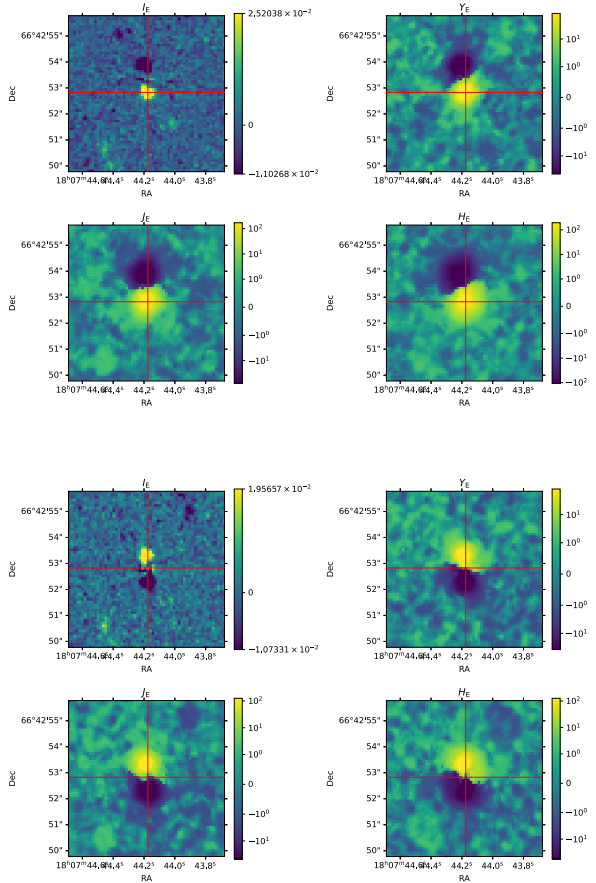
A wide one, consistent with the L/T transition

Angular separation	0.51 ± 0.03 arcsec
Distance	129 pc
Physical separation	66 AU



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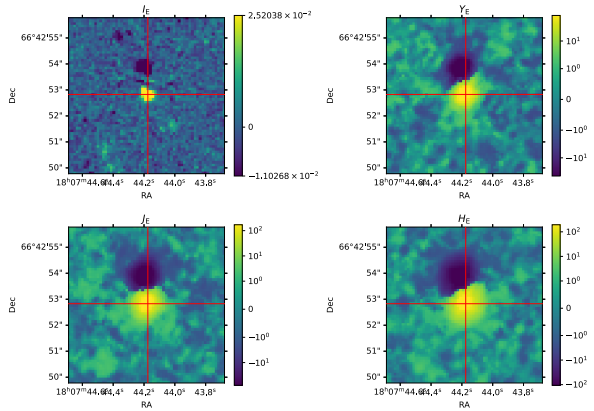
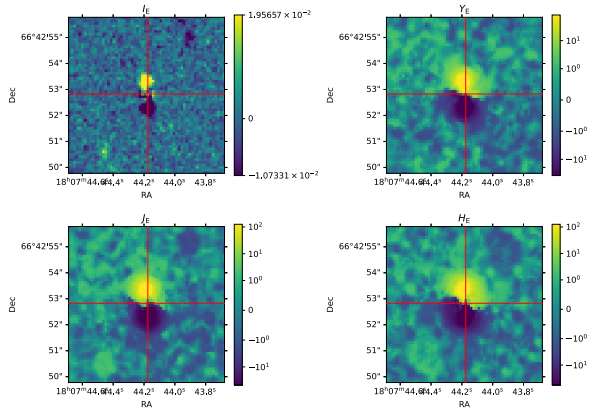
	VIS_E	Y_E	J_E	H_E
Primary	24.223 ± 0.003	20.901 ± 0.002	20.315 ± 0.006	19.766 ± 0.005
Secondary	24.517 ± 0.010	20.907 ± 0.009	20.40 ± 0.02	20.358 ± 0.005
Flux ratio	1.312 ± 0.002	1.005 ± 0.008	1.09 ± 0.03	1.765 ± 0.005





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Inferring the Spectral Type

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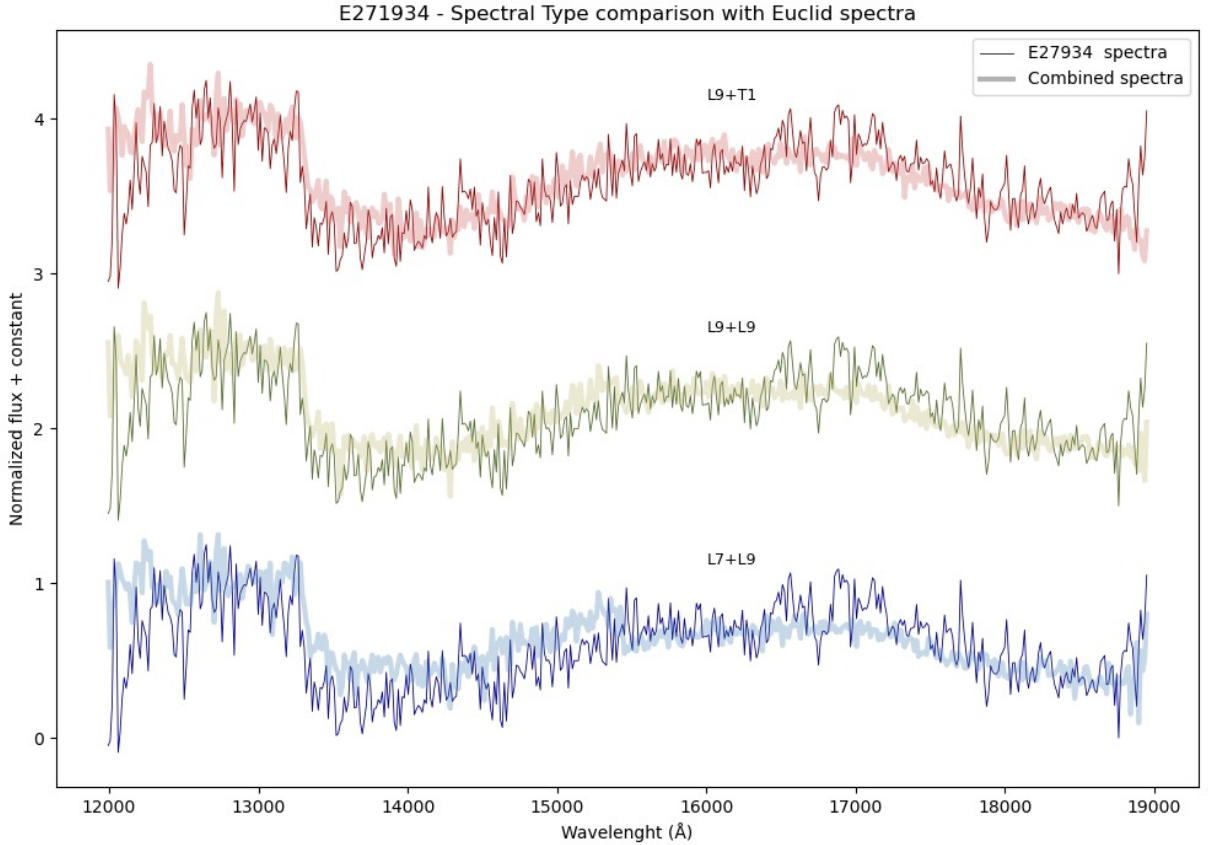

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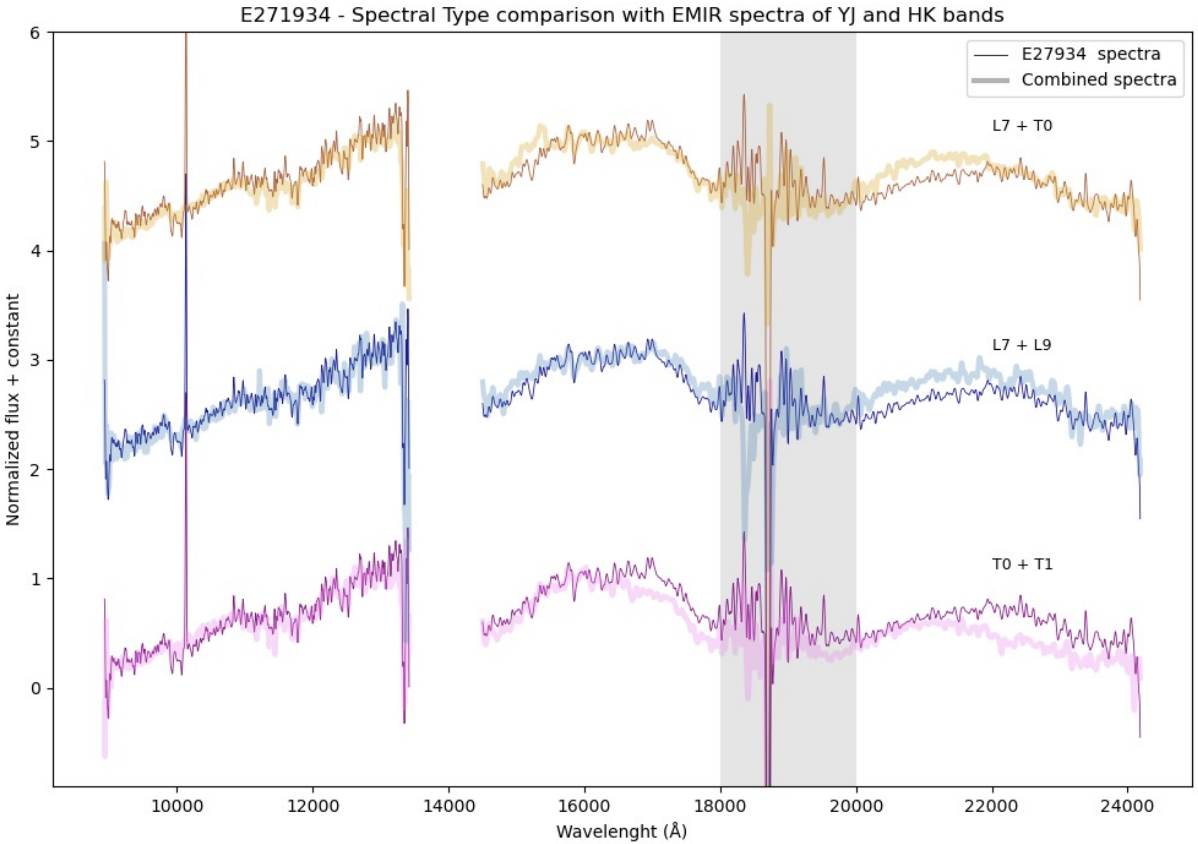

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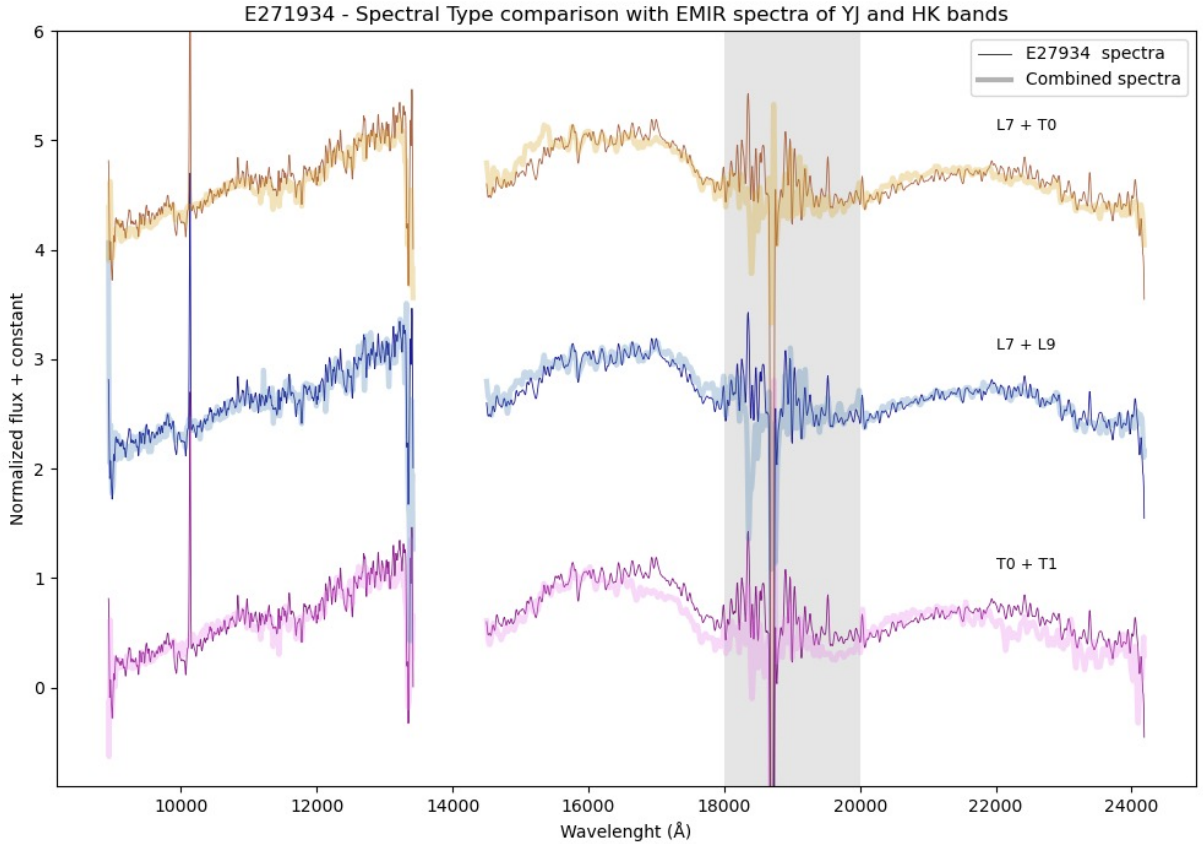

K band flux ratio ➔ 1.4

K band flux ratio ➔ 3.8

K band flux ratio ➔ 0.5

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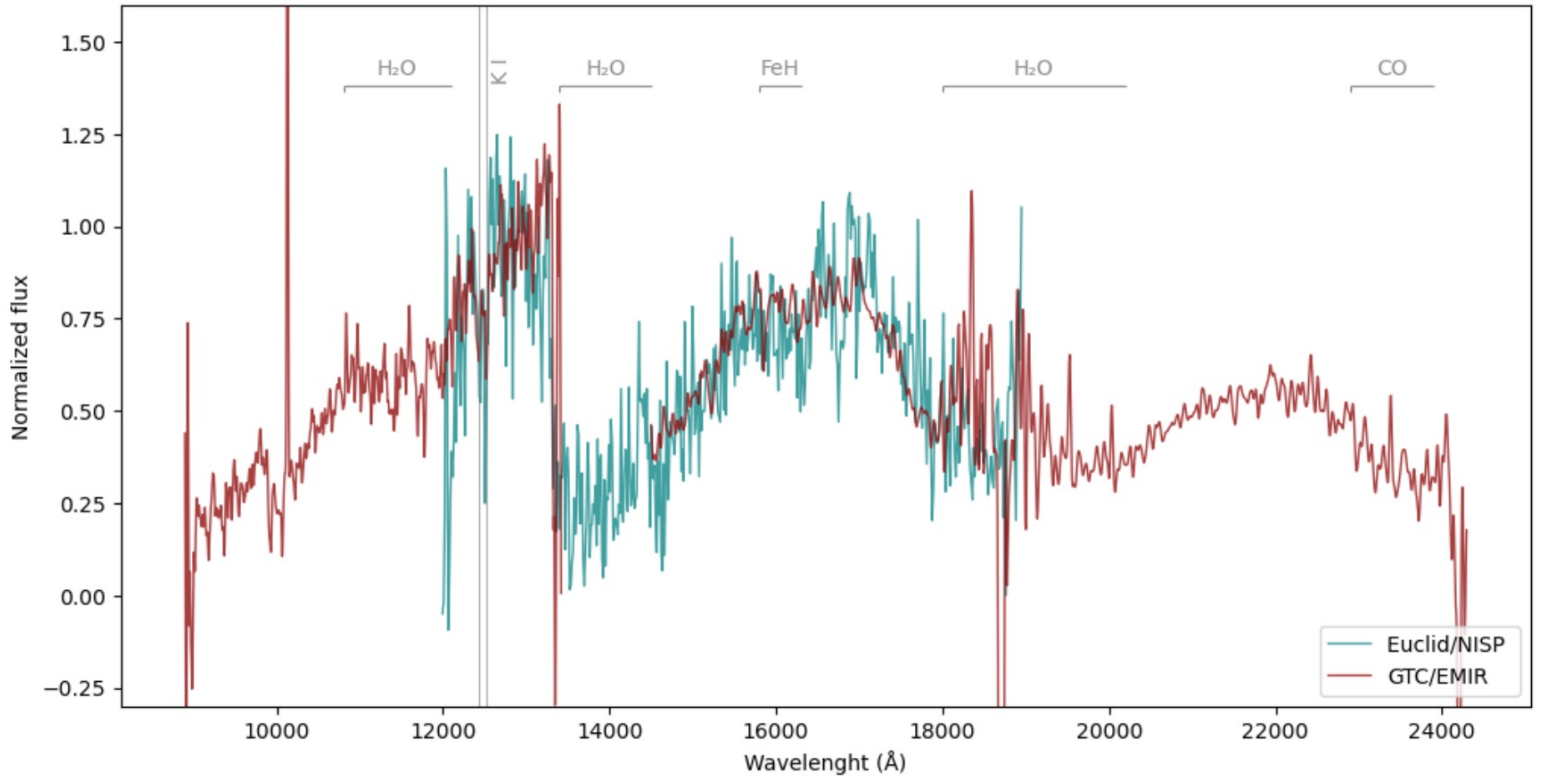
Inferring the Spectral Type – **L7+L9**



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First Field Brown Dwarf Binary discovered with Euclid

We have identified a spatially resolved wide field brown dwarf binary:

➔ At a distance of **~129 pc** and with a physical separation of **~66 AU**

➔ Which photometry and flux ratios are consistent with components in the **L/T transition**, as well as the spectra

➔ The peculiarity of such a wide brown dwarf binary system makes it a valuable target for detailed study

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Towards a complete characterization

Extend the spectral coverage to the optical with OSIRIS at GTC

Search for **atomic lines** (e.g. Li I) to confirm the substellar nature

Derive parameters from atmospheric and evolutionary models

Determine **proper motion and parallax** from multi-epoch observations

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