

CLASSIFICATION AND CHARACTERISATION OF ULTRACOOL DWARFS

超冷矮星的光谱分类与物理特性

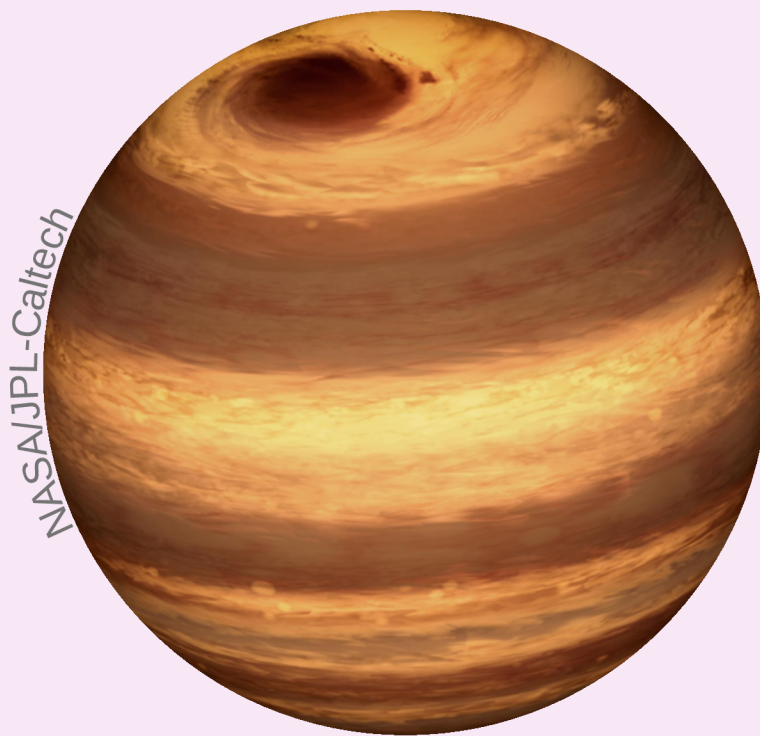
Gemma Cheng

What Are Ultracool Dwarfs?

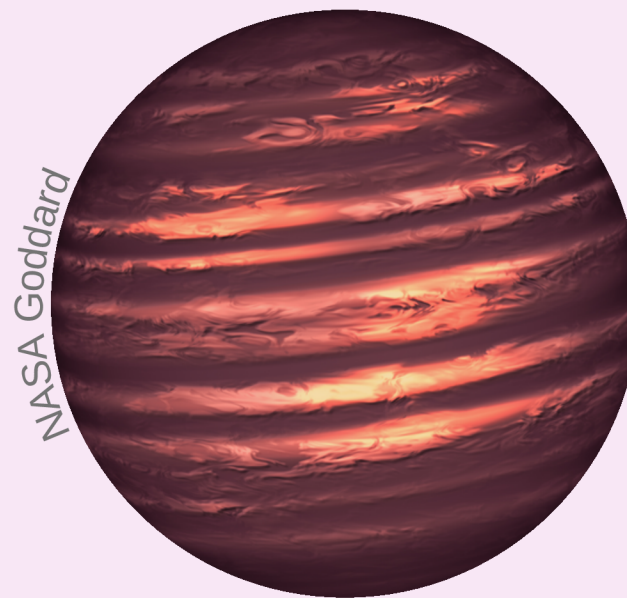
什么是超冷矮星？

Ultracool dwarfs are defined as stellar and substellar objects with spectral types of M7 and later, covering three main types of object

超冷矮星被定义为光谱类型为M7及更晚型的恒星和亚恒星天体，涵盖三类主要天体



Low mass stars
低质量恒星



Brown dwarfs
棕矮星



Planetary mass objects
行星质量天体

Spectral Types

光谱型

Based on the OBAFGKM classification system, extended down to
LTY types for even cooler objects

基于OBAFGKM分类系统，并将其扩展至LTY类型，以涵盖温度更低的天体

Hottest ← → Coolest



O B A F G K M L T Y

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M0 M1 M2 M3 M4 M5 M6 M7 M8 M9 L0 L1 L2 L3 L4 L5 L6 L7 L8 L9 T0 T1 T2 T3 T4 T5 T6 T7 T8 T9 Y0
M L T Y

How Do We Know What The Object Is?

我们如何知道这个物体是什么？

Low Mass Stars

低质量恒星

- Form from collapsing gas and dust in nebulae
由星云中气体和尘埃的引力坍缩形成
- Hydrogen fusion in core
核心中的氢聚变

$$M > 80M_{\text{Jup}}$$

Brown Dwarfs

棕矮星

- Same formation as stars
形成机制与恒星相同
- Below hydrogen fusion mass limit
低于氢核聚变质量下限

$$80M_{\text{Jup}} > M > 13M_{\text{Jup}}$$

Planetary Mass Objects

行星质量天体

- Form via disc accretion
经由吸积盘过程形成
- Below deuterium burning mass limit
低于氘核聚变质量下限

$$M < 13M_{\text{Jup}}$$

Candidate Selection

候选源遴选

Cross match Gaia DR2 with several catalogues of known ultracool dwarfs

将Gaia DR2与多个已知超冷矮星星表进行比对

Full candidate list has 20000+ objects

完整的候选列表包含20000多个对象

67 targets selected for this work, depending on visibility on observing nights

本研究共选定67个观测目标，具体取决于观测当晚的可见度

Which Instruments Did We Use?

我们使用了哪些仪器？

Blanco ARCoIRIS

- Cross-dispersed spectrograph on Blanco telescope in Chile

智利Blanco望远镜上的交叉色散摄谱仪

$R \sim 3000$

$\lambda = 0.80 - 2.40 \mu\text{m}$

IRTF SpeX Prism

- Prism grating spectrograph on IRTF telescope in Hawaii

夏威夷IRTF望远镜上的棱镜光栅光谱仪

$R \sim 200$

$\lambda = 0.70 - 2.52 \mu\text{m}$

IRTF SpeX SXD

- Cross-dispersed spectrograph on IRTF telescope in Hawaii

夏威夷IRTF望远镜上的交叉色散摄谱仪

$R \sim 2000$

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Data Reduction

数据归算

Spectral Extraction

光谱提取

Tracing profiles and
extracting 1D spectral data
from raw observations

基于原始图像的Trace轨迹定
位与光谱提取

01

Order/Exposure Merging

曝光叠合

Combining orders of grating
spectra and consolidating
exposures for each target

光谱级次合并及单目标数据
并合

03

Wavelength Calibration

波长定标

Using lamp arcs to ensure
consistent wavelength
calibrations across spectra

利用定标弧光灯确保全波段
波长定标的精度

02

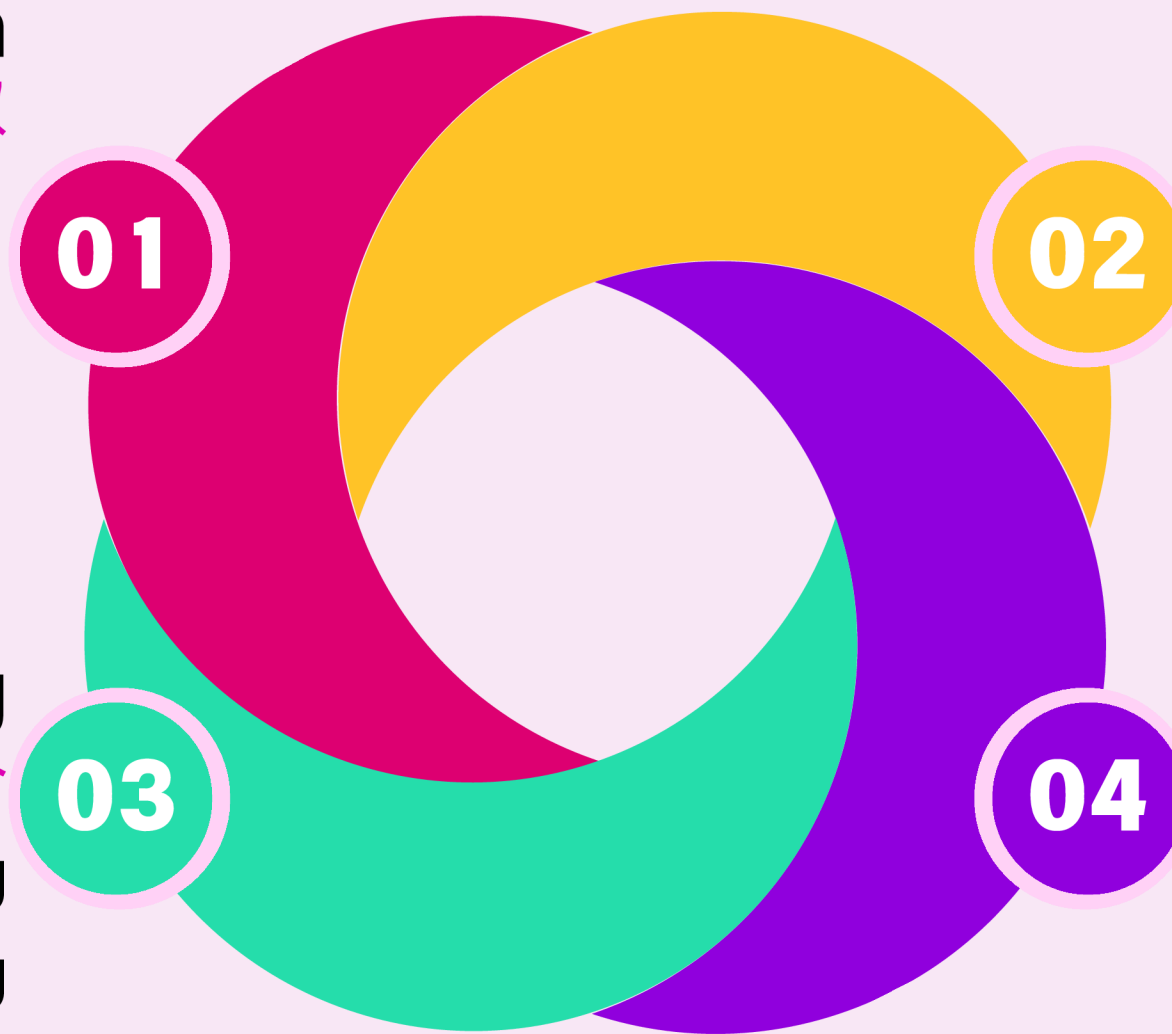
Telluric Correction

碲线校正

Removing Earth's
atmospheric spectral features
using standard stars

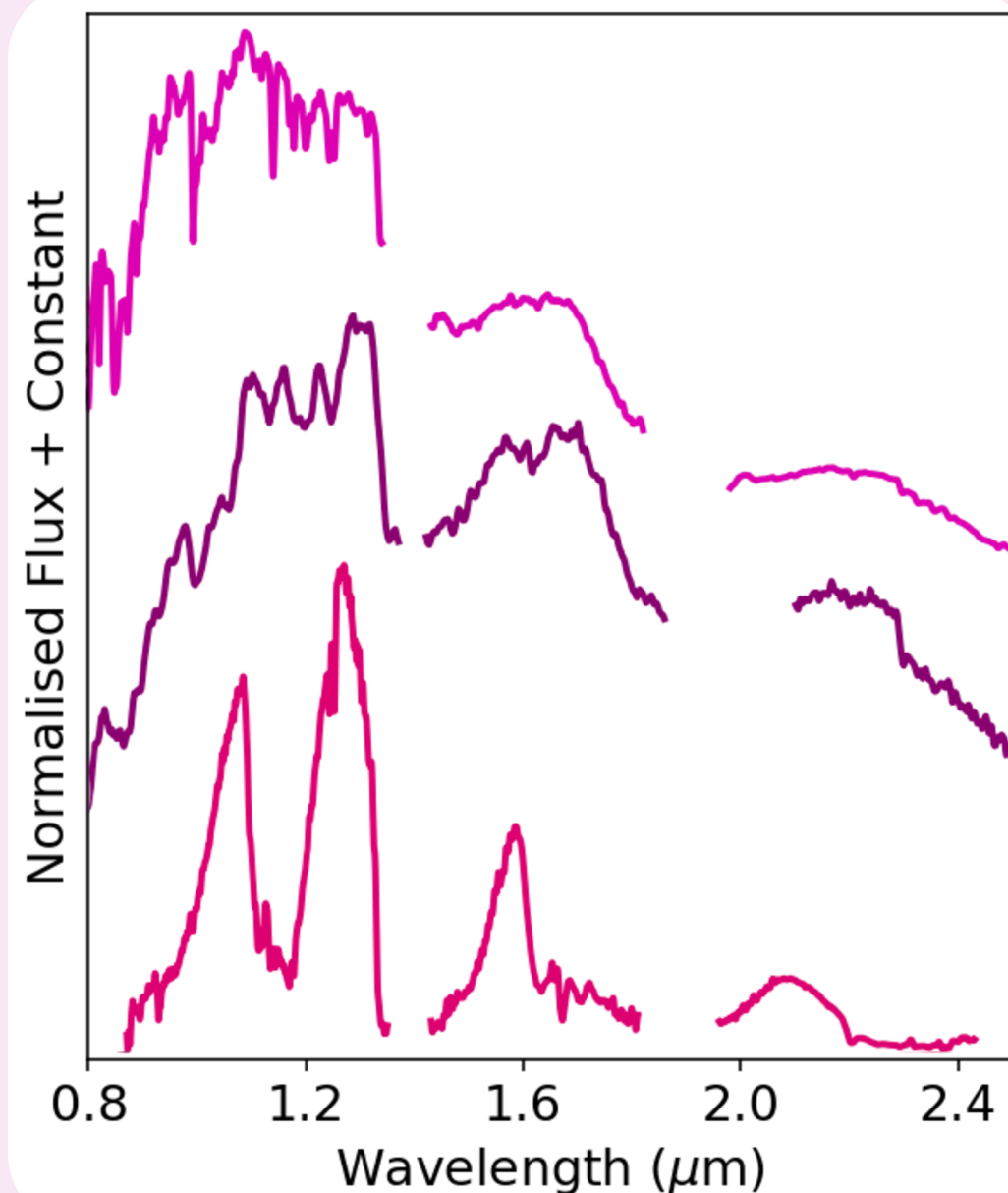
利用标准星去除地球大气的
光谱特征

04



The Spectra

观测光谱



Adapted from Cheng+25

M-type M型光谱

- Notable spectral features include TiO and FeH
典型光谱特征包括显著的TiO与FeH分子带
- Sawtooth-shaped *J*-band
J波段的锯齿状特征

L-type L型光谱

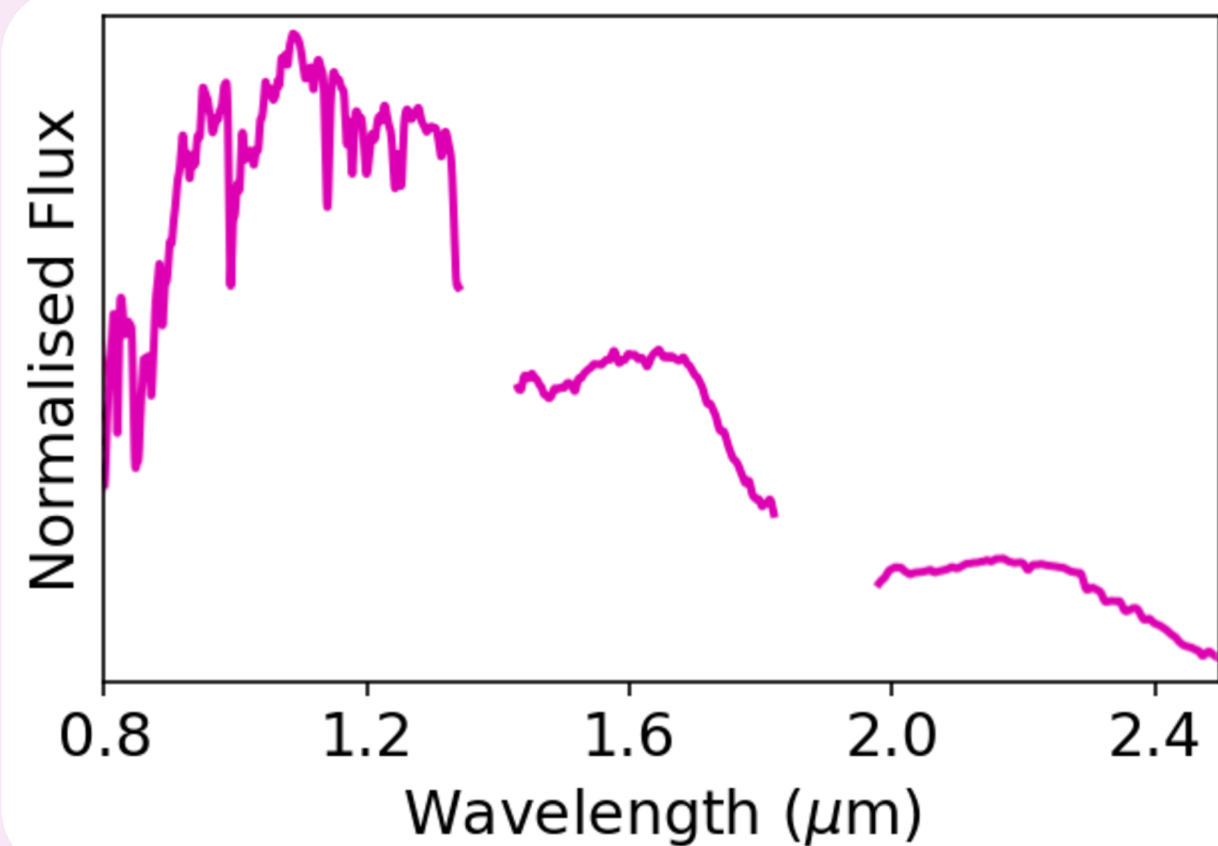
- Prominent alkali absorption (e.g. Na I, K I)
显著的碱金属吸收线(Na I, K I)
- Spectrum smoothed by dust
由大气尘埃消光导致的平滑连续谱

T-type T型光谱

- Spectrum dominated by methane absorption
受甲烷主导的光谱形貌
- Peak spectral morphology
具有峰值形貌的光谱轮廓

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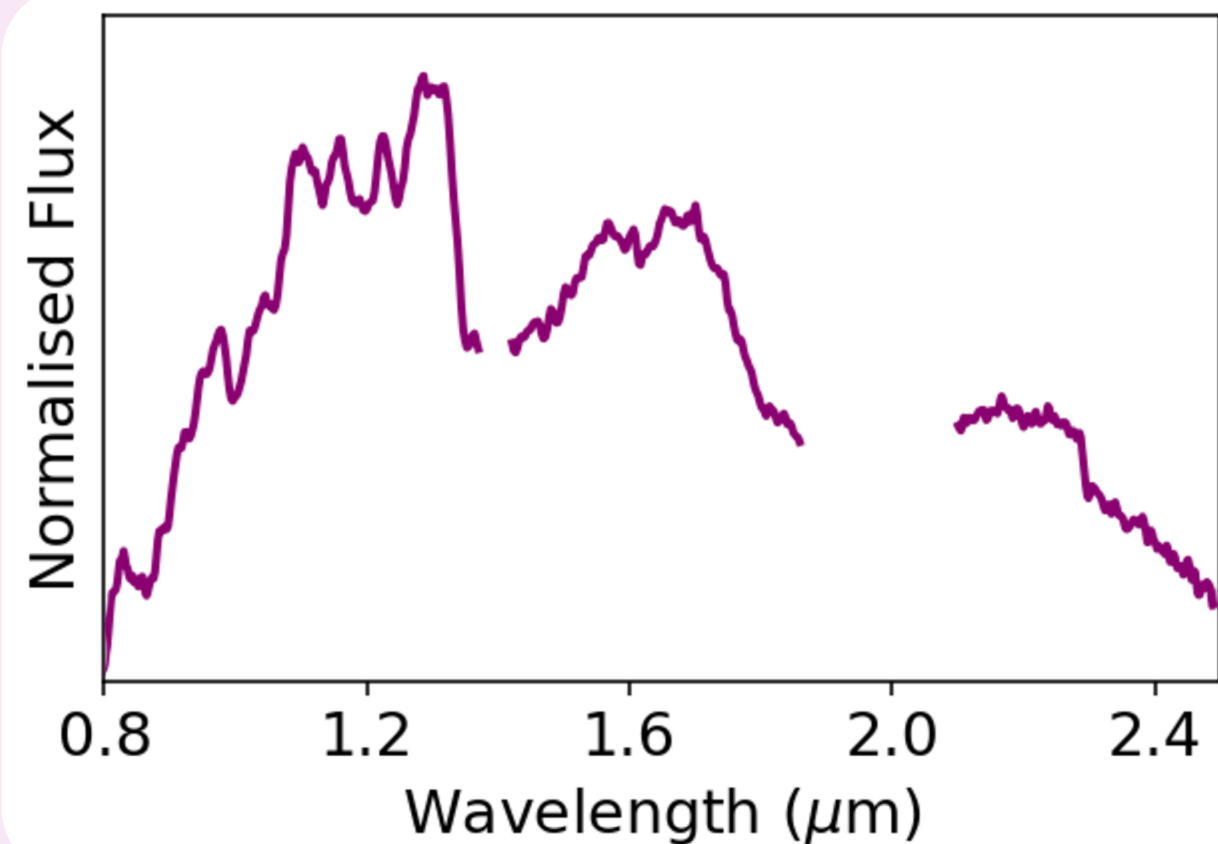
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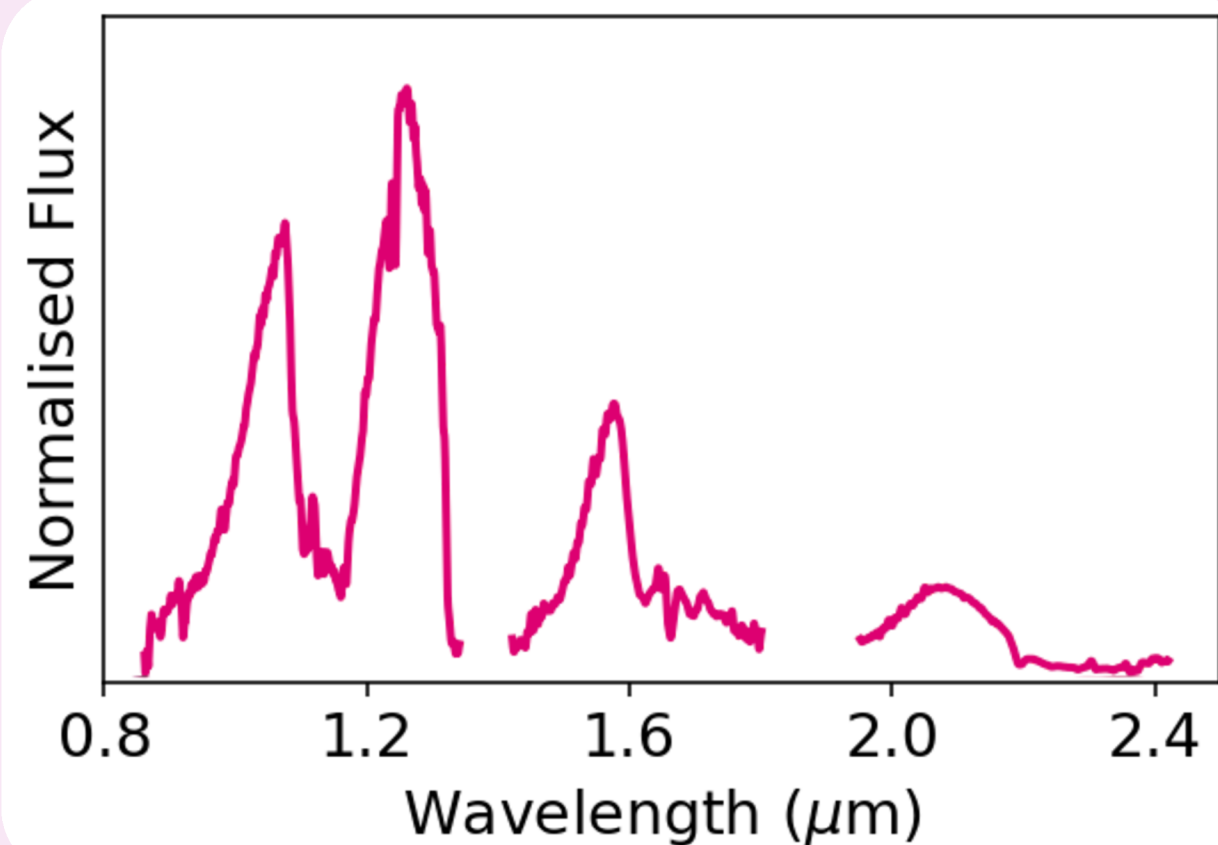
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Spectral Classification

光谱分类

Photometric Spectral Types

测光光谱型

Using NIR colours to estimate spectral type from published colour-spectral type relationships

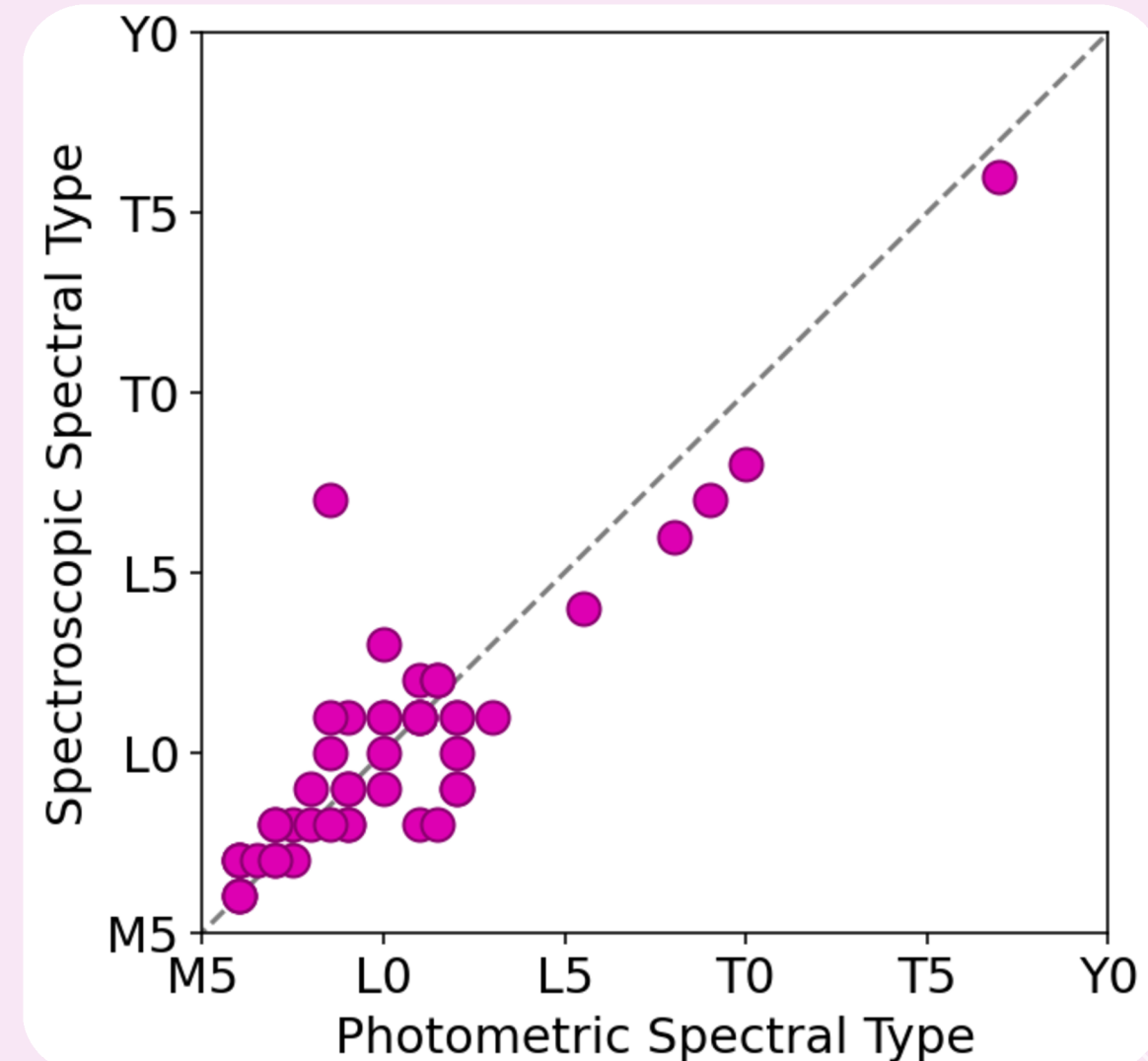
基于已发表的颜色-光谱型经验关系，利用近红外色指数估算光谱型

Spectroscopic Spectral Types

实测光谱型

Using standard spectra to fit to observations to determine spectral type

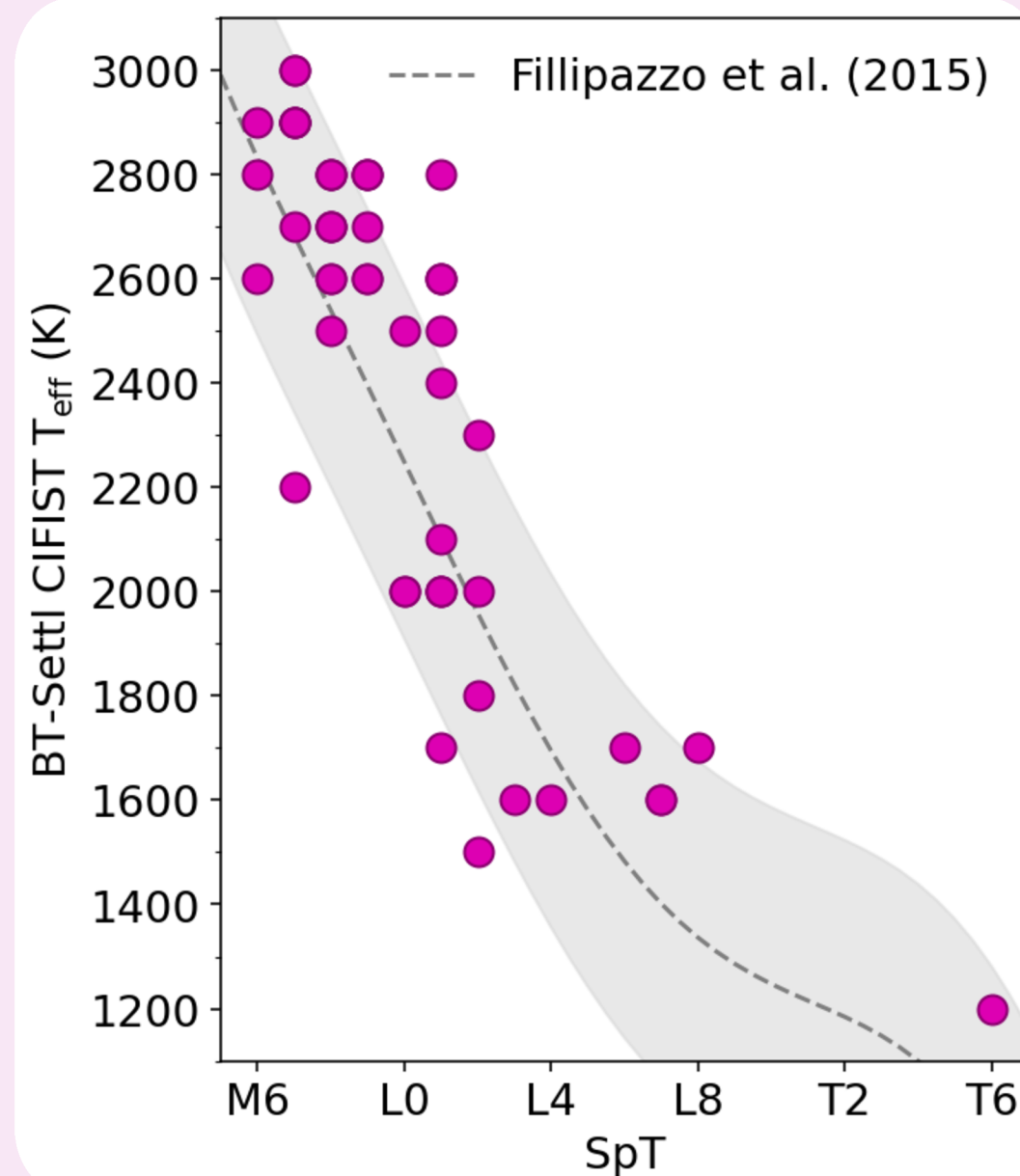
采用模板匹配法进行光谱定型



Adapted from Cheng+25

Characterising Physical Properties

物理性质表征



Adapted from Cheng+25

Forward Modelling

前向建模

Finding effective temperature using BT-Settl grids

利用BT-Settl模型网格约束有效温度

Radial Velocity Measurements

径向速度测定

Using cross correlation and line centering to measure RVs

利用互相关和线中心定位法测量径向速度

Toomre Diagrams

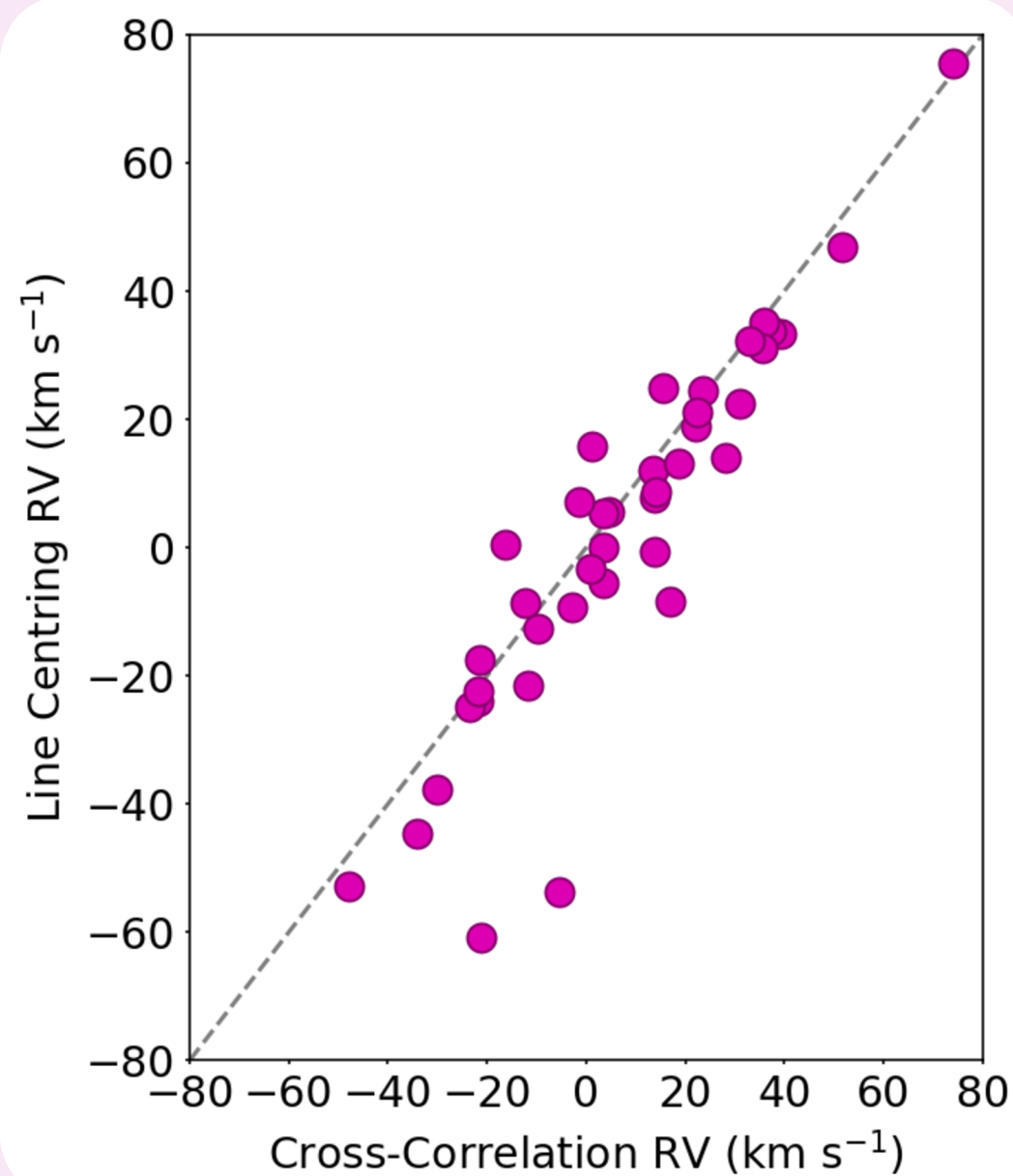
图姆雷图

Using UVW to find Galactic population kinematic membership

基于UVW速度的空间运动学成员判定

Characterising Physical Properties

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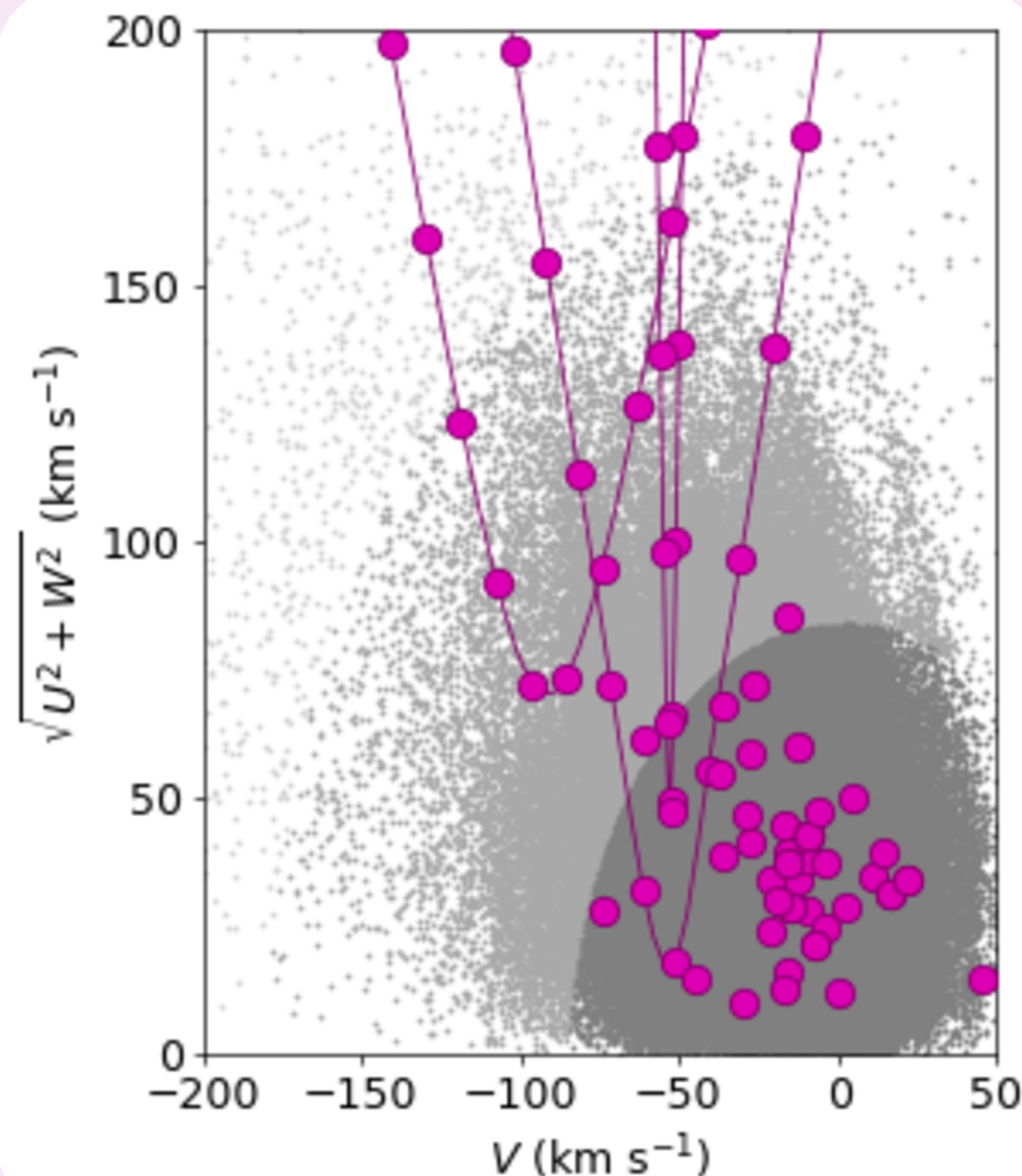
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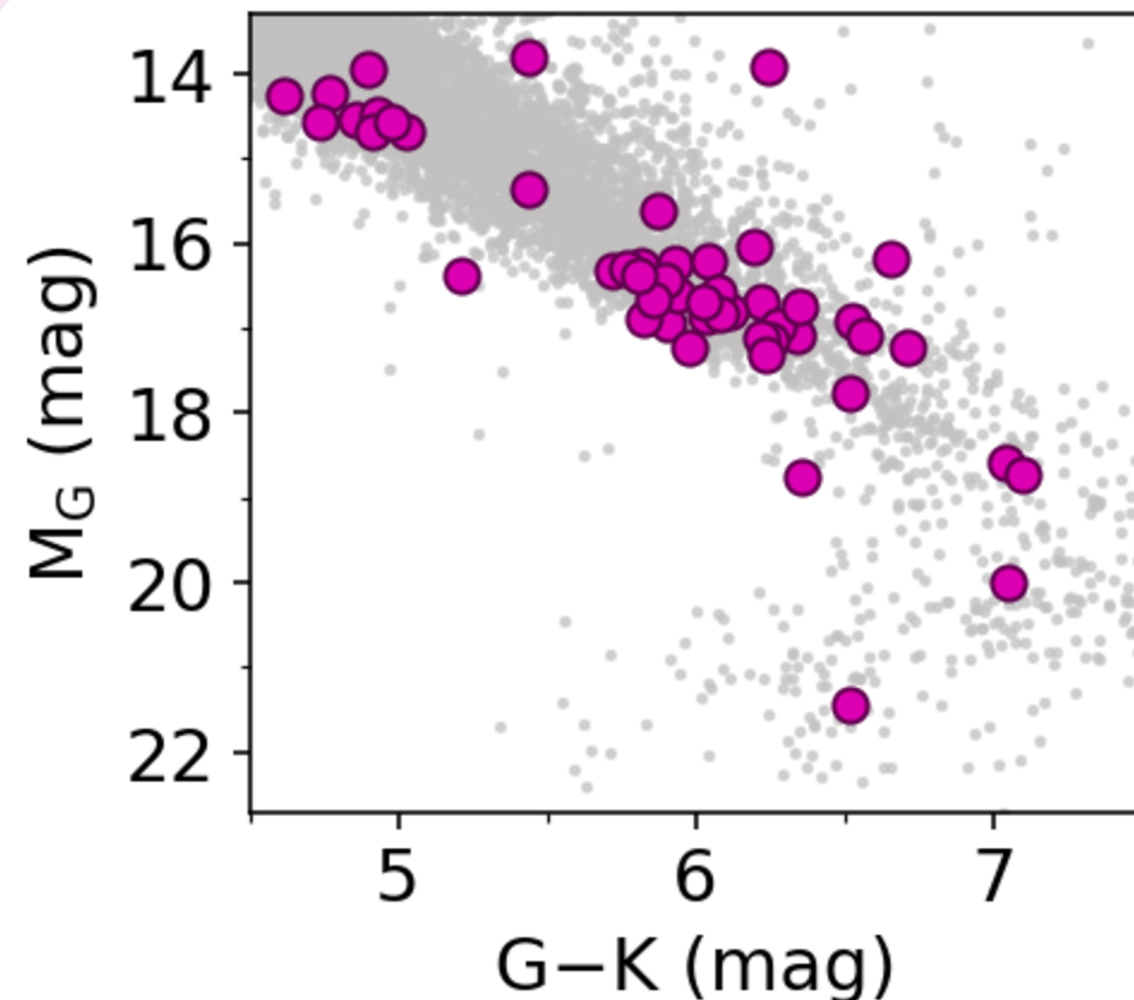
基于UVW速度的空间运动学成员判定

Identifying Unusual Objects

特殊天体的证认

We used various methods to identify any unusual objects in the sample

我们采用了多维度的方法来识别样本中的特殊天体



Adapted from Cheng+25

Colour-Magnitude Diagrams

色-星等图

Used to identify any objects with unusual colours

特殊颜色目标的探测

Common Proper Motion

共同自行

Used to identify co-moving wide binaries

用于识别共动宽双星

Gaia RUWE Parameter

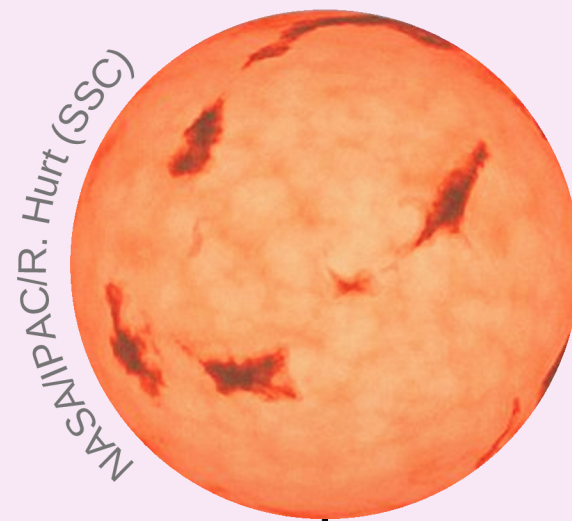
Gaia重新归一化的单位权重误差(RUWE)参数

Used to identify unresolved binary candidates

未解析双星系统的搜寻与证认

Summary Of Sample Properties

样本基本性质综述

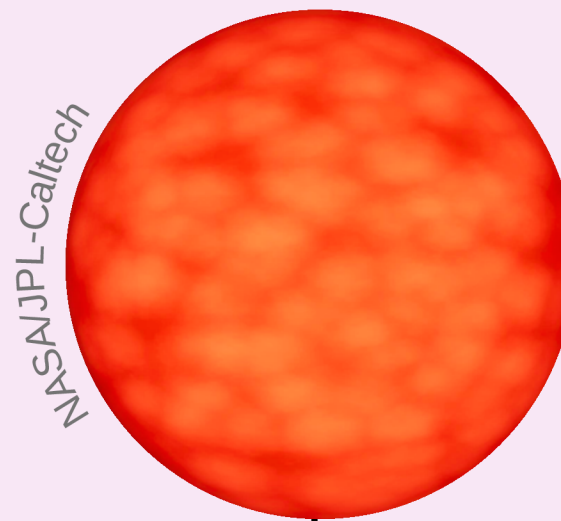


M-Types

M型天体

26 objects

26颗

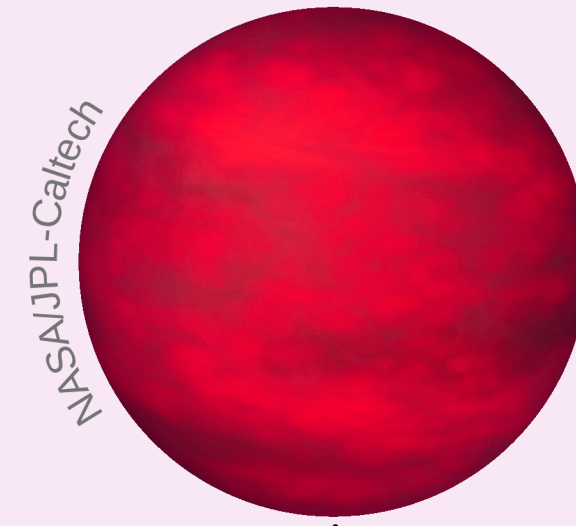


L-Types

L型天体

24 objects

24颗



T-Types

T型天体

1 object

1颗

+ 16 objects classified earlier than M7

+16颗早于M7型的天体

Summary Of Sample Properties

样本基本性质综述



Young UCDs

年轻的超冷矮星

7 objects

7颗

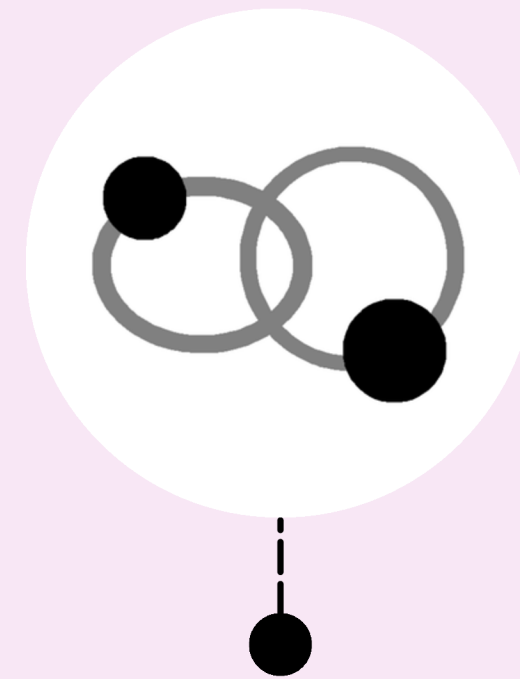


Thick Disc/Halo UCDs

银晕及年老超冷矮星

4 objects

4颗

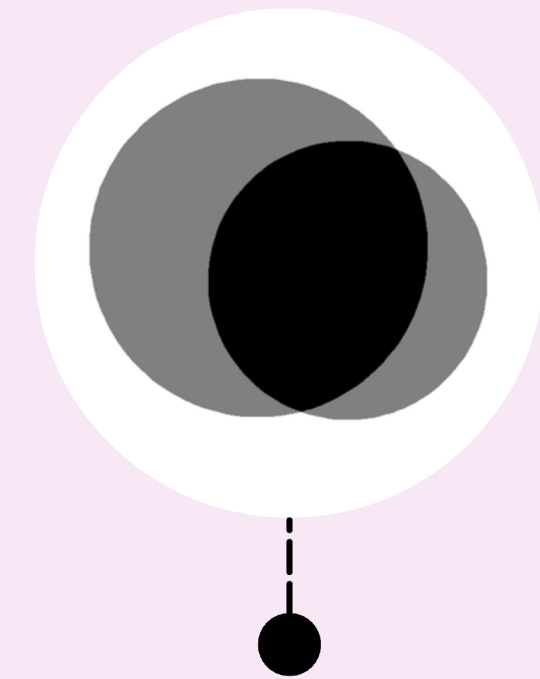


Wide Binaries

宽双星

6 objects

6颗



Unresolved Binaries

未解析双星

6 objects

6颗

THANK YOU 😊

谢谢

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