Brown dwarfs represent one of the cases in Astrophysics, where theory was ahead of the observation. They were first predicted to exist by theoretical studies from the early 1960s (Kumar, 1963; Hayashi & Nakano, 1963) and it took over 30 years for these predictions to be observationally confirmed by the first discoveries (Rebolo et al., 1995; Nakajima et al., 1995). Some call them failed stars, others, oversized planets. Anyhow, brown dwarfs can be regarded as intermediate objects between the least massive stars and the massive gas giant planets. They have masses in the range from approx. 13 to 75 Jupiter masses and effective temperatures typically below 2,500 Kelvin. Unlike stars, brown dwarfs are unable to ignite and sustain stable hydrogen fusion in their cores and thus, without an internal source of energy, they gradually cool down and fade during their evolution.

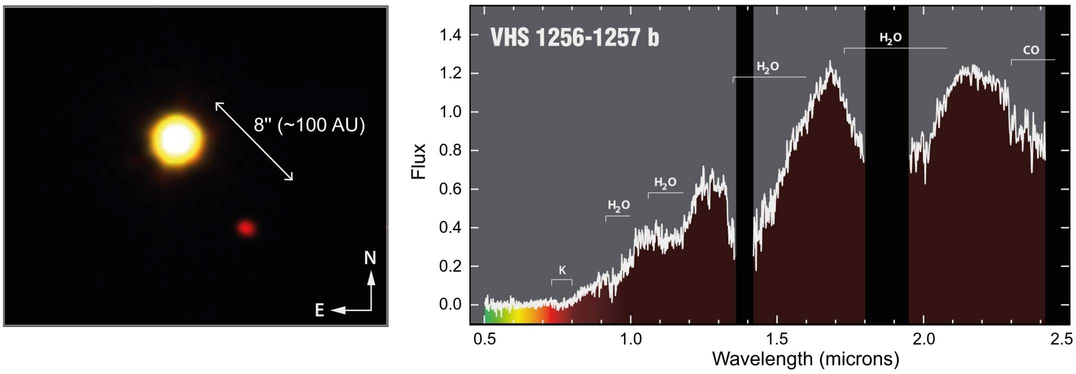

Figure 1: A representative example of the kind of systems we expect to identify and study. *Left:* False colour VISTA YJK_s-bands image of the young M dwarf VHS 1256-1257 and its L7-type planetary mass companion, discovered using the early VISTA Hemisphere Survey data (Gauza et al., 2015). *Right:* low-resolution optical and near-infrared spectra of VHS 1256 b. Main spectroscopic features are indicated.

Because of this progressive cooling, it is not possible to determine the mass of a brown dwarf (or more generally, of a substellar object, the mass of which is below the H-burning mass limit) just by measuring its luminosity, not knowing its age. In other words, an object of a 2,000 K temperature can be either an old, very low-mass star, a brown dwarf at an age of the Solar System, or, a very young massive planet. Because they are so faint, it is also extremely difficult to measure their distances or metallicities. Fortunately, substellar objects that form binary and multiple systems with stars provide an immediate solution to this problem. We can infer the distance and metallicity from the brighter, much easier to characterize primary star and, most importantly, we can use it to constrain the age of the system. This in turn enables a thorough characterization of the fundamental physical properties of the substellar companion.

The primary goal of this project is to identify and characterize brown dwarf and planetary mass companions to stars. We propose to employ the latest large-scale sky surveys, like the near-infrared VISTA Hemisphere Survey (VHS) or the mid-infrared *Wide-field Infrared Survey Explorer* (*WISE*) to carry out an extensive search for such substellar companions by identifying common proper motion objects. We aim to study the physical and atmospheric properties of brown dwarfs and massive planets spanning broad ranges of temperatures, masses, metallicities and ages. To achieve that, we will pursue four complementary pathways of research focusing on: **A)** Y-dwarf companions to stars from the solar vicinity. **B)** companions to white dwarfs and metal-poor primaries, **C)** ultracool (i.e., of an M7 spectral type or later) companions to high proper motion ($\mu \geq 100$ milliarcseconds per year) stars and **D)** companions to known members of young moving groups and stellar associations. In **Group "A"** we aim to find the coldest brown dwarfs – the Y dwarfs, to study the first ever Y-type companion to a main sequence star and explore the properties of objects at <600 K. **Group "B"** will concern the metal poor low-mass dwarfs and brown dwarfs of the old (>5 Gyr) population. In **Group "C"** we will look for late-M, L and T companions at wide (50–10,000 au) orbits around high proper motions stars. In **Group "D"** we intend to find young (<500 Myr) Ls and Ts, being analogues of giant exoplanets.

For the candidates selected in the four groups we will obtain follow-up imaging and spectroscopic observations, to confirm them as true companions and to determine their spectral types, temperatures, masses and other fundamental parameters, thus making them to become the so-called benchmark objects (like the example shown in Fig. 1) that can serve as reference points to test and improve evolutionary and atmosphere theoretical models. The methods developed within our group, like for example the *WISE* multi-epoch images stacking, and the unprecedented sensitivities of the employed surveys gives the opportunity to unveil the coldest, least massive substellar companions known to date, which will become prime targets for further detailed studies using upcoming facilities like the Extremely Large Telescope or the *James Webb Space Telescope*.