The Initial Mass Function:

Three science cases on low mass objects for the E-ELT

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Why three cases?

- IMF is a very broad topic –many proposals possible
- They highlight different capabilities of the telescope
- They require different instrumental capabilities
- They highlight different contributions to the topic

Case I: characterizing the lowest mass freely-floating objects

Goal: spectroscopic characterization of the lowest-mass freely-floating objects in nearby star forming regions (masses in the few-Jupiter range)

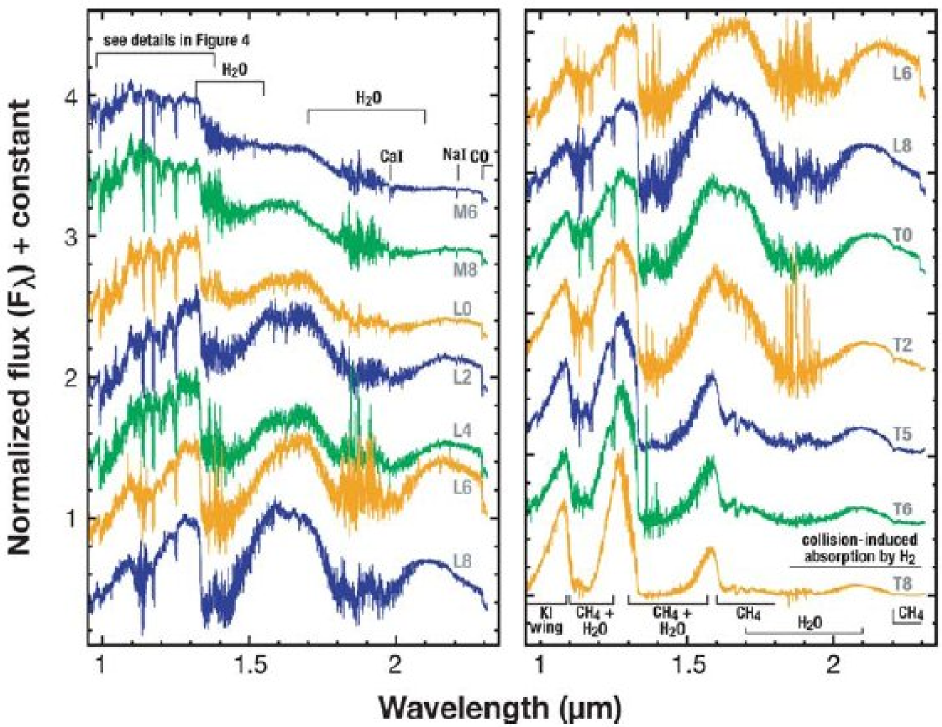
- To derive physical properties based on next-generation models of ultracool stellar atmospheres through temperature- and gravity-sensitive features
- Meteorology through time monitoring
- Targets to be supplied by next generation infrared imaging surveys, possibly reaching down to the opacity limit; identified from colors, but detailed spectroscopy possible only with ELTs.

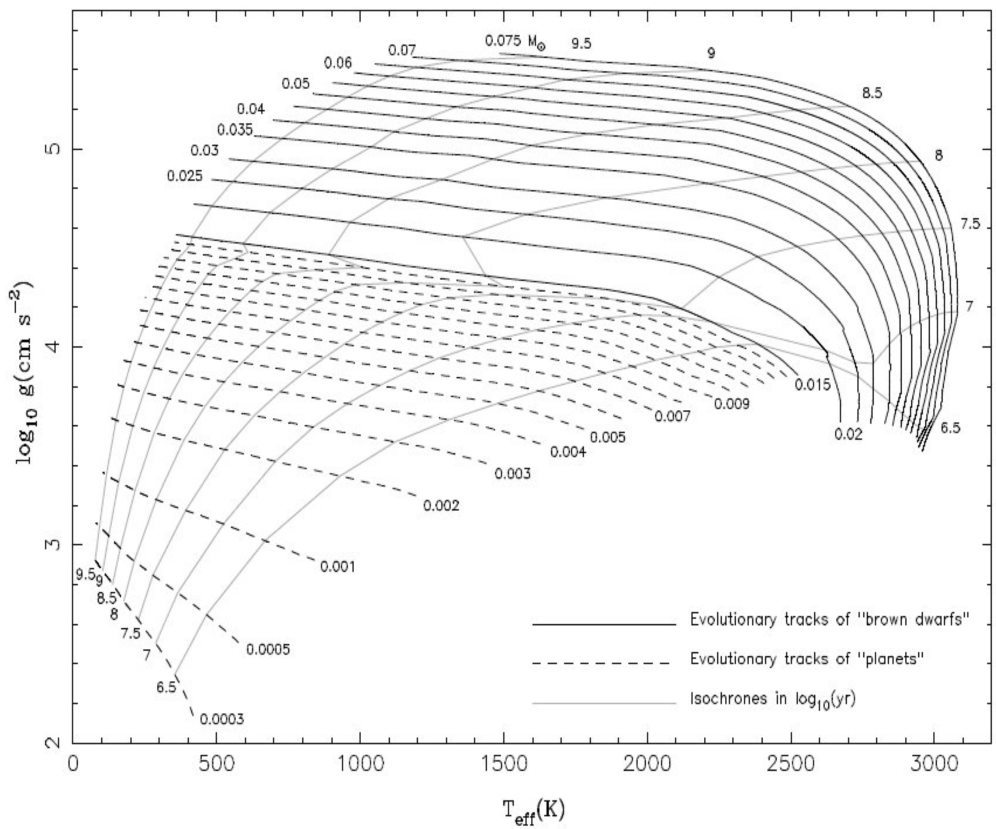
Case I: characterizing the lowest mass freely-floating objects

Complete IMF may be known in the nearest star forming regions by the time the E-ELT enters operations

- Faint end of the IMF is still uncharted territory in T – log g.
- Similar objects know in the field (T dwarfs), but with very different masses and surface gravities; existing observations of a handful of objects yield photometric evidence for significant differences

Case I: characterizing the lowest mass freely-floating objects





Case I: characterizing the lowest mass freely-floating objects

Atmospheres of these objects are quite complicated

- Complex chemistry
- Dust formation and disappearance below the photosphere (grain size-dependent)
- Clouds and weather patterns
- Time monitoring an important part of the characterization:
    - High S/N to be collected in a time span limited by the rotation of the object (periods ~12h)
    - Several timescales to be sampled: hours (rotational modulation), days/weeks (genuine weather pattern evolution)
- Linkage to intrinsic properties (mass, age) would be uncertain at present: interpretations of the results will depend on advanced models yet to be produced.

Case I: characterizing the lowest mass freely-floating objects

The E-ELT case:

- Need to obtain high S/N in a short time span at faint magnitudes; at DM=6.0,
  - At 5 Myr, 1 Mjup: I=26.3, J=22.8, H=22.6, K=23.0 (T-like)
  - At 5 Myr, 3 Mjup: I=23.5, J=19.9, H=19.6, K=16.2 (L-like)

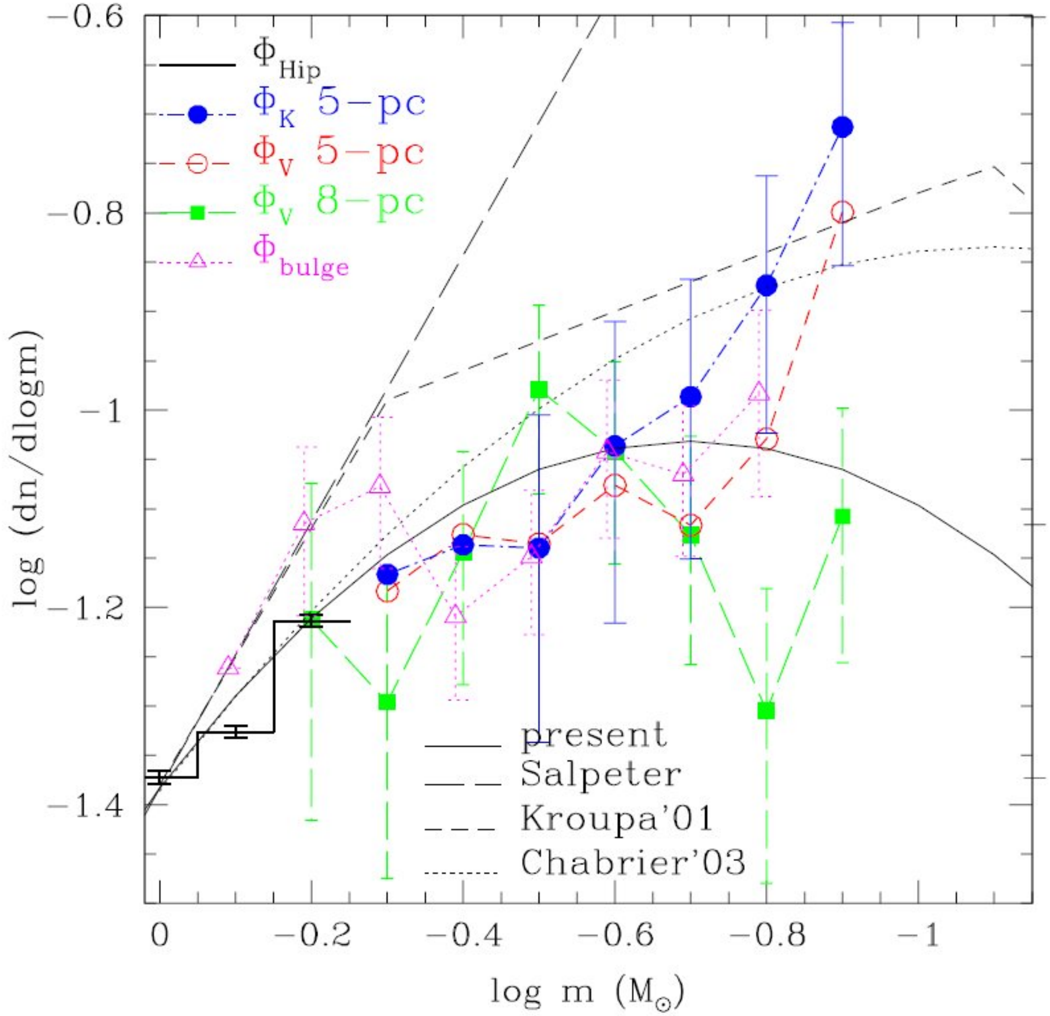
    (…but is there a L/T transition at such low g's? where?)
- Exposures limited to ~2h due to rotation
- Monitoring on different timescales (hours/weeks)
- If opacity limit is at ~few Mjup, this could be a case for "non-AO bright nights"
  - What mass limits could be reached in the nearest star forming regions?
  - Performance in the visible far-red (gravity-sensitive atomic features)
- Case for the visible/infrared IFU spectrograph shortward of 2.5 microns
- Performance beyond 3 microns (MIDIR) can be investigated.

Case III: the low-mass IMF at the Magellanic Clouds

Goal: deriving the IMF in LMC/SMC fields down to 0.2 Msol

- By the time the E-ELT enters operations, the solar neighbourhood IMF will be determined with excellent accuracy by GAIA:
  - All stars above the substellar limit up to 10 pc
  - All stars with mass above 0.1 Msol up to 100 pc
  - Follow-up spectroscopy may reveal IMF evolution with metallicity
- Determination of the IMF between 0.8 and 0.2 Msol at the LMC/SMC is extremely robust:
  - At those masses, IMF=PDMF
  - All stars at the same distance
  - Extinction negligible in the infrared
  - Pre-main sequence evolution still short at those masses: M can be directly derived from the main-sequence L-M relationship
- Metallicity effects (40% solar LMC, 15% solar SMC) on the IMF should be readily visible if existing by comparing to the solar vicinity IMF.

Case III: the low-mass IMF at the Magellanic Clouds



Case III: the low-mass IMF at the Magellanic Clouds

The E-ELT case:

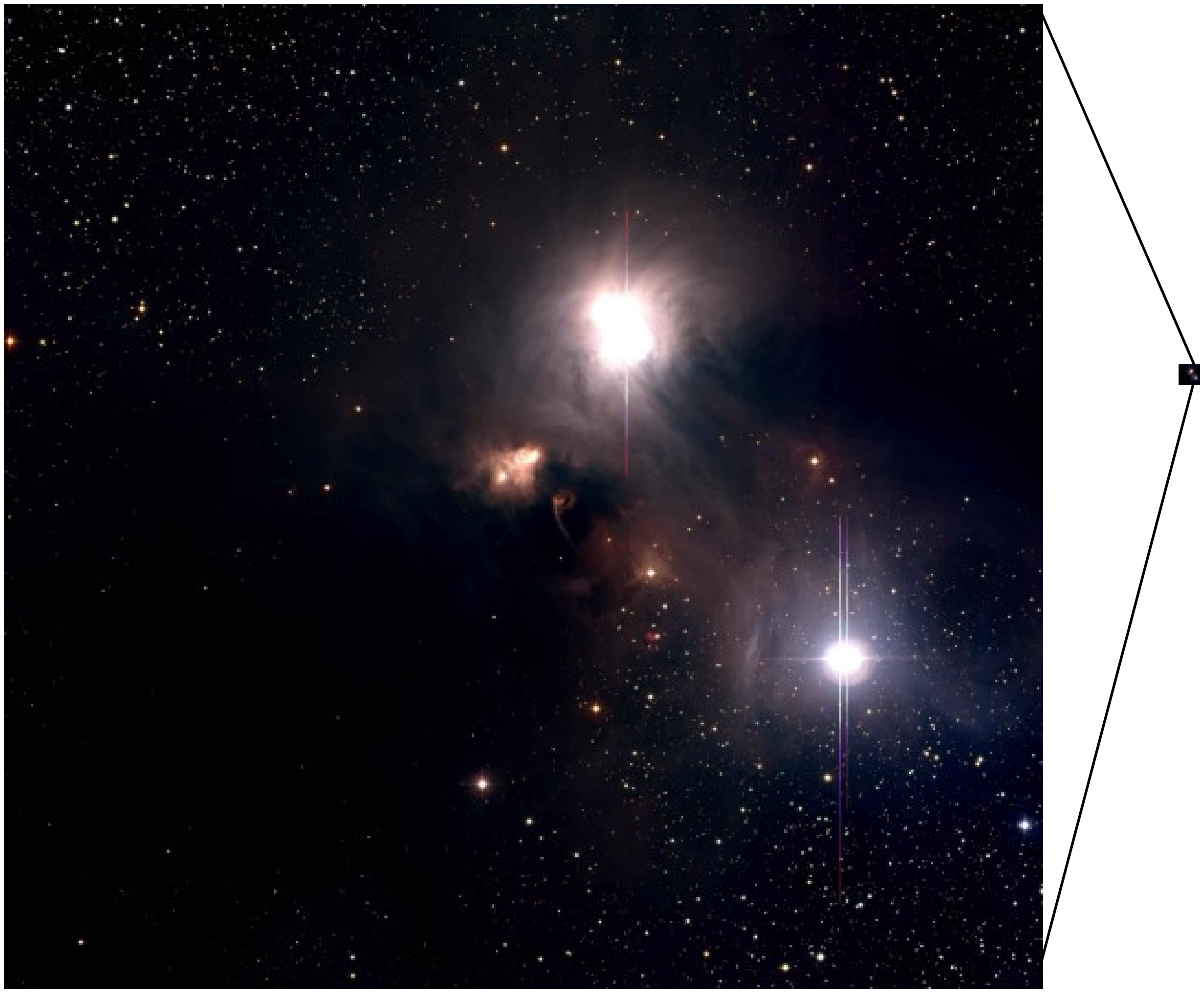
- Taking up where HST left: HST-based derivations reach down to 0.7 solar masses, without finding evidences for metallicity effects
- Expected crowding: ~1 star per sq. arcsec (bar/disk transition).
- Required limits (S/N = 10): J=27.6, H=26.5, K=26.
- GLAO case: 13h at J, 35 at H, 40 at K.
- Instrument to be used LTAO/MCAO diffraction-limited imager, in GLAO mode.
- Several fields to be observed (87h per field).
- Question for DRM analysis: what are the admissible limits in crowding given the range of color and magnitudes expected? (realistic PDMFs in color-magnitude space will be provided).

Case IV: giant-planet-like objects in the LMC

Goal: probe the complete mass function down to ~5 Mjup in a LMC star forming region

- How does the opacity limit depends on metallicity?
- What do low-mass, low metallicity brown dwarfs look like?
- Low metallicity, low mass brown dwarfs virtually invisible in our Galaxy:
    - 5 Mjup objects formed together with the Sun now have absolute H magnitude ~28.8; undetectable beyond ~100,000 AU.
- Accessible only if the LMC/SMC, where low-metallicity brown dwarfs are being formed now.
- In a 1 Myr-old star forming region at the LMC, a 5 Mjup object should have J= 29.1, H=28.7, K=28.2 (possibly different because of different metallicity)

Case IV: giant-planet-like objects in the LMC



Crowding is an important issue: a region like R CrA would be ~2 arcsec across and have a (roughly estimated) density of ~20 objects/sq arcsec

Case IV: giant-planet-like objects in the LMC

The E-ELT case:

- LTAO needed to boost sensitivity and spatial resolution
- Angular size makes possible to obtain a good LTAO correction over the entire star forming region if a bright star exist (centrally dominant Herbig Ae/Be?) –Complete surveys with LTAO…
- Project could actually be "easier" if the opacity limit ends the IMF at ~10 Mjup at the LMC distance (~1 mag brighter)
- Instrument of reference is LTAO/MCAO diffraction-limited imager.
- DRM simulations should include the LMC declination (-69)
- Photometric accuracy required at the ~0.1 mag level –is it at all possible given the brighter members of the region?
- Times: 7h for J=29.1, 8h for H=28.7, 10h for K=28.2
- Possibility to include bright embedding nebulosity