Some Considerations for High Resolution IR Spectroscopy at the TMT

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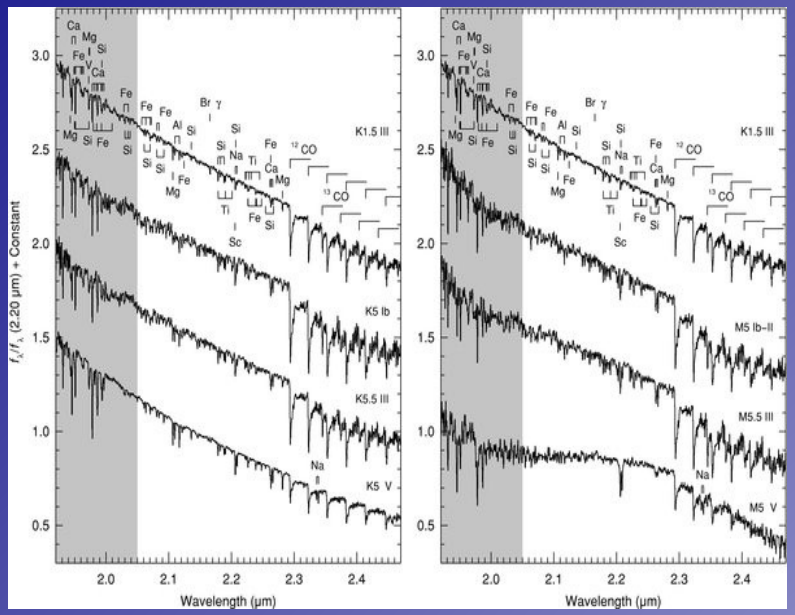
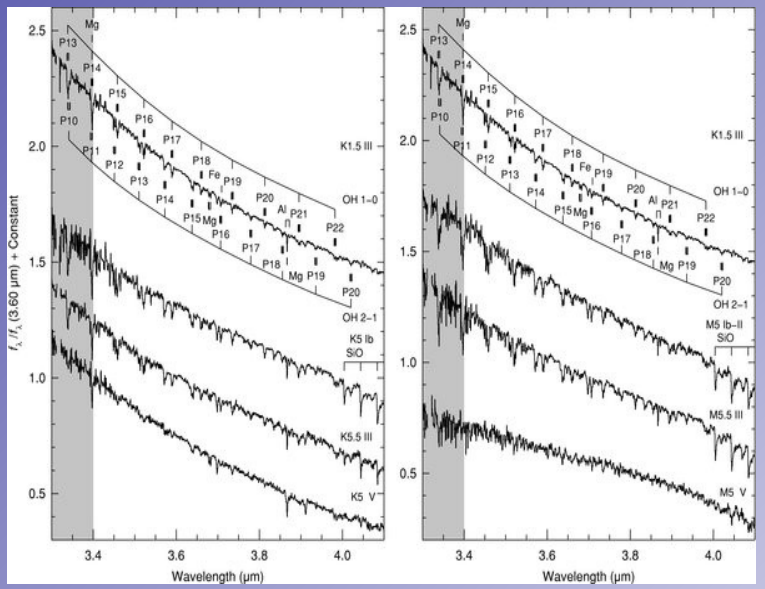
NIRES & MIRES: SAC Specs

- NIRES
  - 1 – 5um
  - R = 20000 -> 100000
  - 2 arcsec slit
- MIRES
  - 8 – 18um (4.5 – 28um goal)
  - R = 5000 -> 100000
  - 3 arcsec slit

There is latitude to fine tune these based on the science case for the final instrument (e.g. the MICHI study).

An Introduction to the NIR and MIR Absorption Spectrum for the Uninitiated





Figures 32 and 22 of Rayner et al. (2009)

The near and mid-IR regions contain many features that are probes of chemical composition and log(g). The Rayner et al. spectra shown here have a resolution ~ 2000.

The IR Absorption Spectrum (Con't)

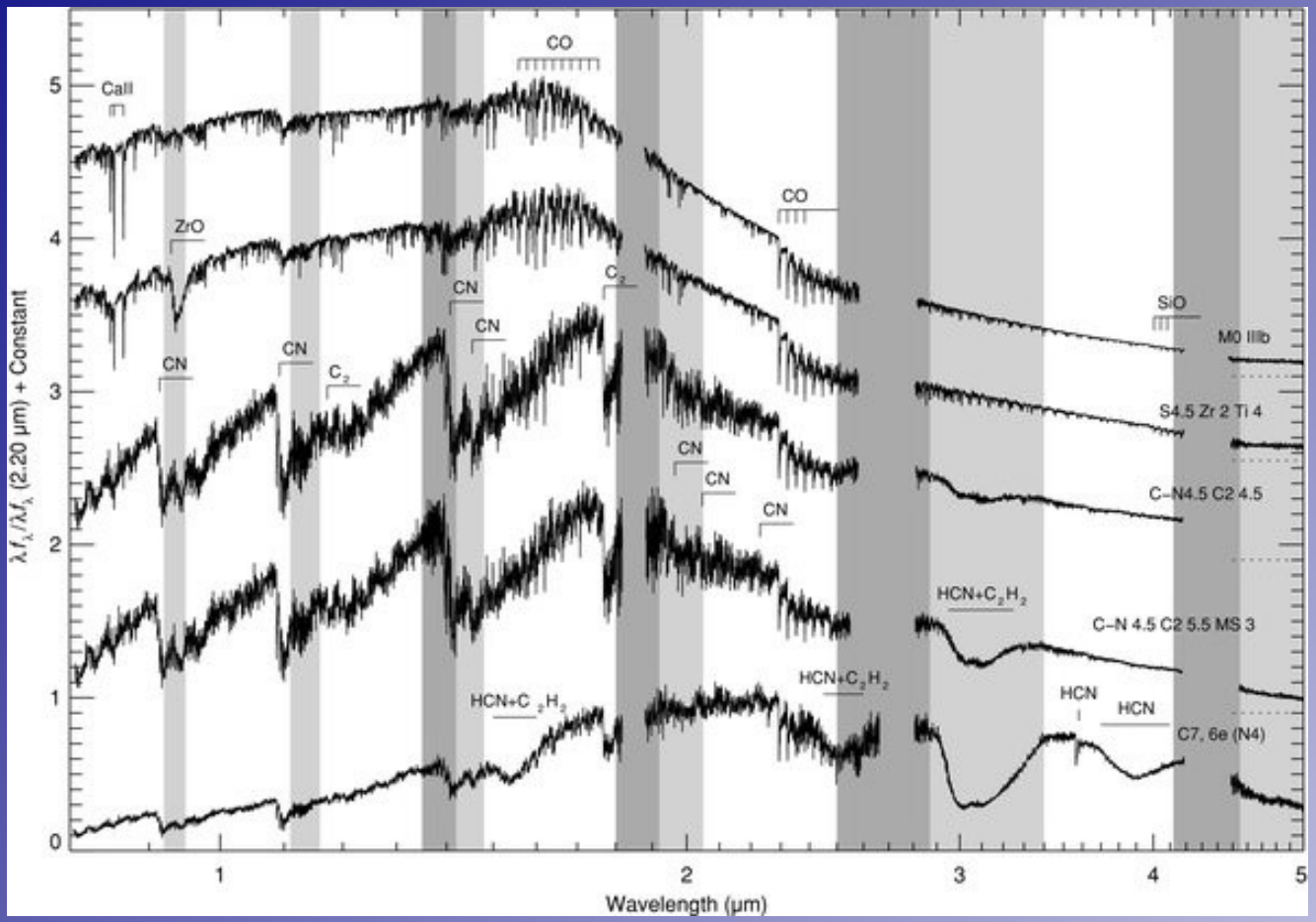


Figure 34 of Rayner et al. (2009)

The near and mid-IR wavelength regions contain useful features for studies of stellar populations, such as numerous CN bands, the Ballick-Ramsey C2 bands and the HCN+C2H2 complex near 3.1um.

Complementary Capabilities to the JWST: (1) Angular Resolution

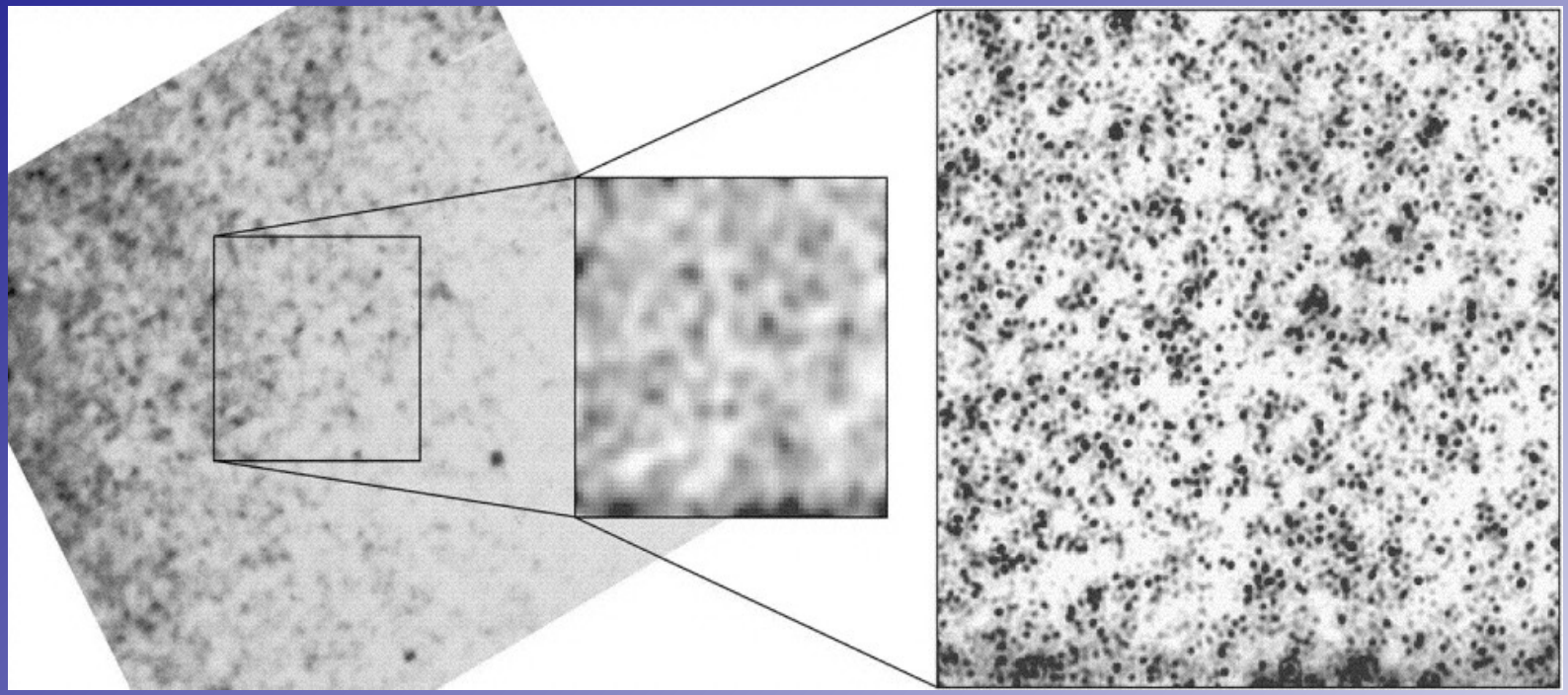


Figure 15 of Stephens et al. (2003)

Complementary Capabilities to the JWST: (2) Spectral Resolution

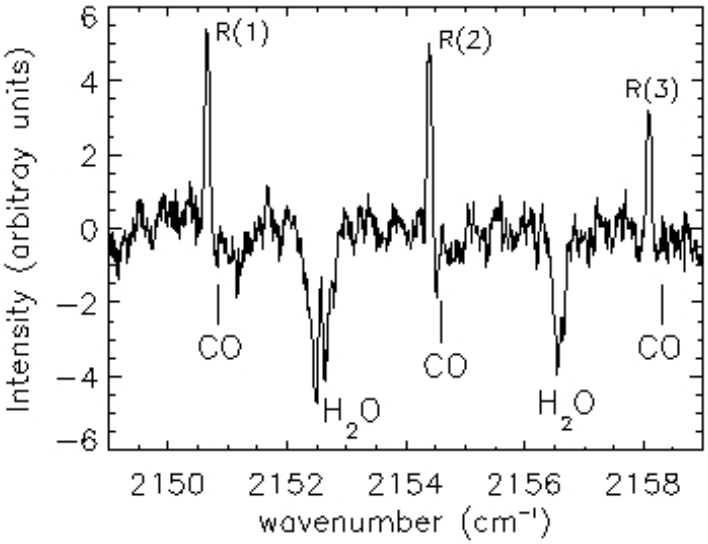


Fig. 2. An example of a subtracted spectrum (see text); in this case the emission spectrum 4″ North of **R Leo**. The telluric lines are indicated in the lower part of the figure. The telluric water lines usually vary more and faster than the telluric CO lines. In this spectrum the telluric CO lines have not changed very much, whereas the water lines have varied more between the on-star and the off-star exposures. When subtracting the two spectra, the telluric lines can either go below or ove zero depending how they have varied. From the amplitude of the CO emission lines and the noise (which includes both photon niose and spurious mismatch between on-star and off-star spectra, cf. Fig. 1) we estimate a S/N of at least 5

From Ryde et al. (1999)

R=40000 spectrum of CO fundamental bands in the envelope around R Leo. These would be hard to detect with resolutions of a few thousand.

Complementary Capabilities to the JWST: (3) A Long Lifetime

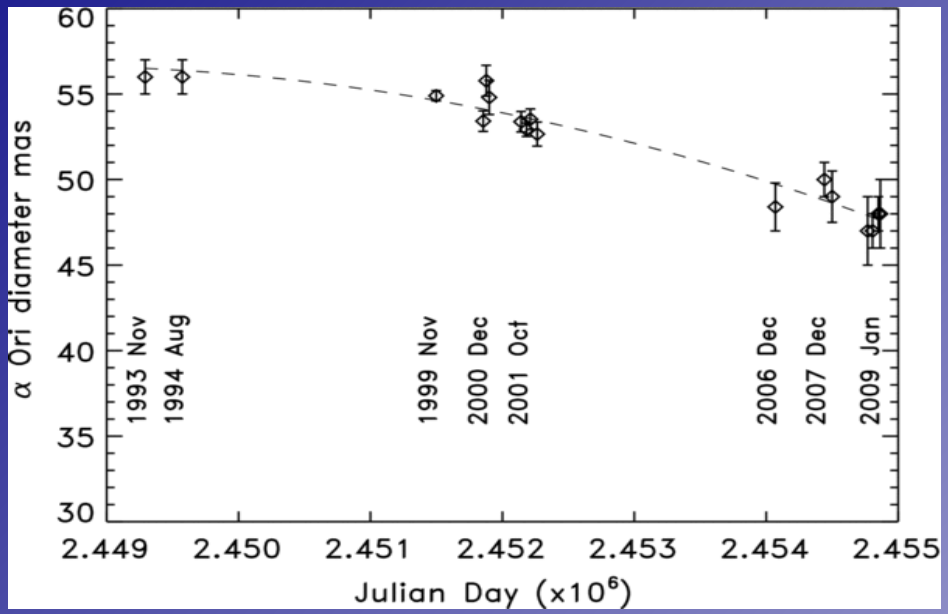


Figure 1 of Townes et al. 2009, showing change in the size of Betelgeuse over 15 years.

Note: With interferometric techniques the VLTs can match (and exceed) the angular resolution of the TMT.

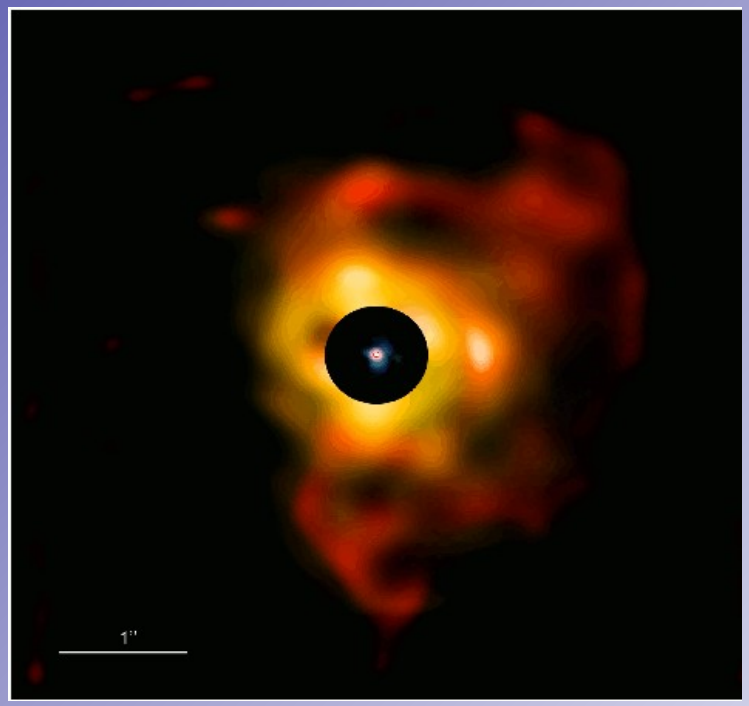
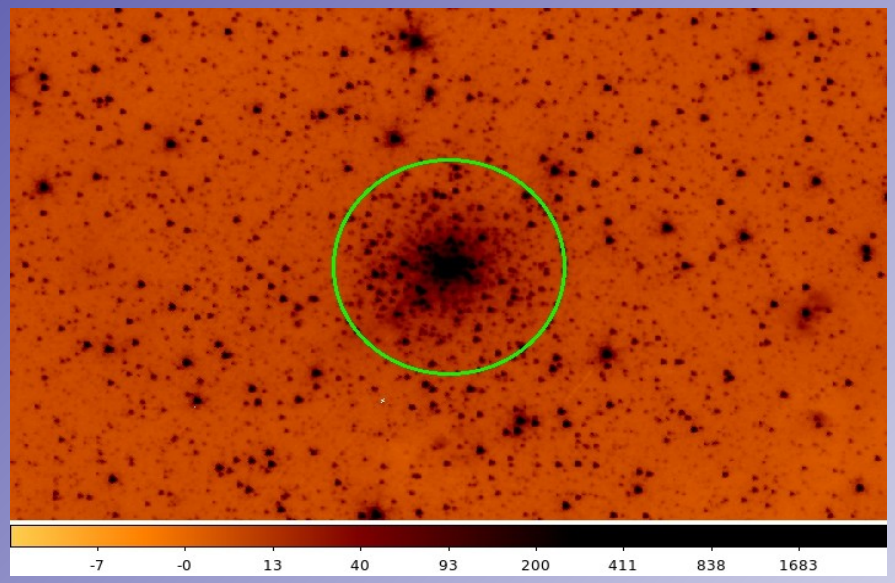


Figure 12 of Kervella et al. 2011, showing NIR and MIR structure around Betelgeuse. VLT NACO and VISIR observations.

With the TMT it will be possible to probe variations over timespans of many years. This is important for tracking – say – material ejected from stars.

Increasing Observing Efficiency

- **NFIRAOS will deliver a 2 arcmin corrected beam, and IRIS has only one IFU.**
- **A group of Canadian astronomers, lead by a team at the Dunlap Institute, are working to develop a multi-IFU system to deploy behind GeMS, based on experience gained with RAVEN.**
- **Could NIRES be fed by such a system? (Potential targets: stars in dense Galactic fields, star clusters in nearby galaxies, etc).**



IRAC [3.6] image of the highly extincted cluster Glimpse C01. What are the chemical compositions of the member stars, and what is the age of the cluster?

MOAO as a feed for NIRES and MIRES to Achieve Even Larger FOVs?

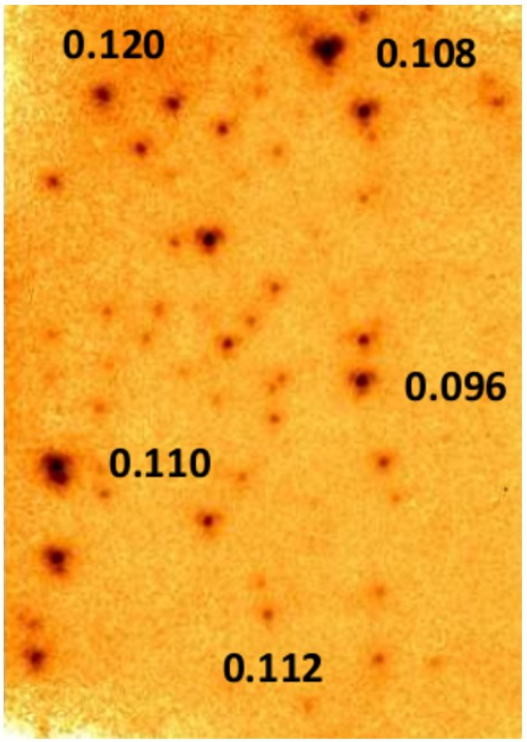


Fig. 1. Final processed H_2O ($\lambda_{cen} = 3.05\mu m$) image of GC01 in one science pick-off. A 3.1×4.5 arcsec area is shown. The total exposure time is 80 seconds, and the FWHMs of selected sources are indicated. The mean FWHM is 0.11 arcsec, whereas $\lambda/D = 0.08$ arcsec for an 8 meter telescope at this wavelength. The diffuse halo around each source is the Airy pattern.

3.1 micron image of the central regions of GC01 from Davidge et al. (2016, submitted).

At wavelengths longward of 2.5 microns RAVEN delivered images in long exposures that were comparable to the Subaru diffraction limit.

The Final Slide

- The second generation NIR and MIR spectroscopic capabilities of the TMT sample portions of parameter space where there are obvious niches that can be exploited. These same niches also provide workhorse capabilities.
- We should view the guidelines for the instruments defined by the SAC as notional at this point, and should not be afraid to modify them based on well thought-out science cases.
- We should be innovative, and examine ways to improve observing efficiency (e.g. multiple IFU systems).
- ***How does the scientific performance of MIRES change with site characteristics like altitude? Is there a line in the sand?***
- ***How do we negotiate the wavelength overlap between HROS and NIRES-B? What is the best strategy for observing astrophysically important features like FeH at 0.99um?***
  - ***Should we consider HROS and NIRES-B as a `system', designed in tandem to maximize performance? Does not have to be X-Shooter like.***