The E-ELT Science Case

Science Pep Talk #3

9 Prominent Science Cases

“Prominent” science cases are considered to be among the most important scientifically and are useful for defining capabilities of the telescope.

- Planets and Stars
  - **From giant to terrestrial exoplanets: detection, characterization and evolution**
  - **Circumstellar disks**
  - **Young stellar clusters**
- Stars and Galaxies
  - **Imaging and spectroscopy of resolved stellar populations in galaxies**
  - **Black holes and AGN demographics**
- Galaxies and Cosmology
  - **Physics of high redshift galaxies**
  - **First light – The highest redshift galaxies (z>10)**
  - **Is the low-density IGM metal-enriched?**
  - **A dynamical measurement of the expansion history of the Universe**

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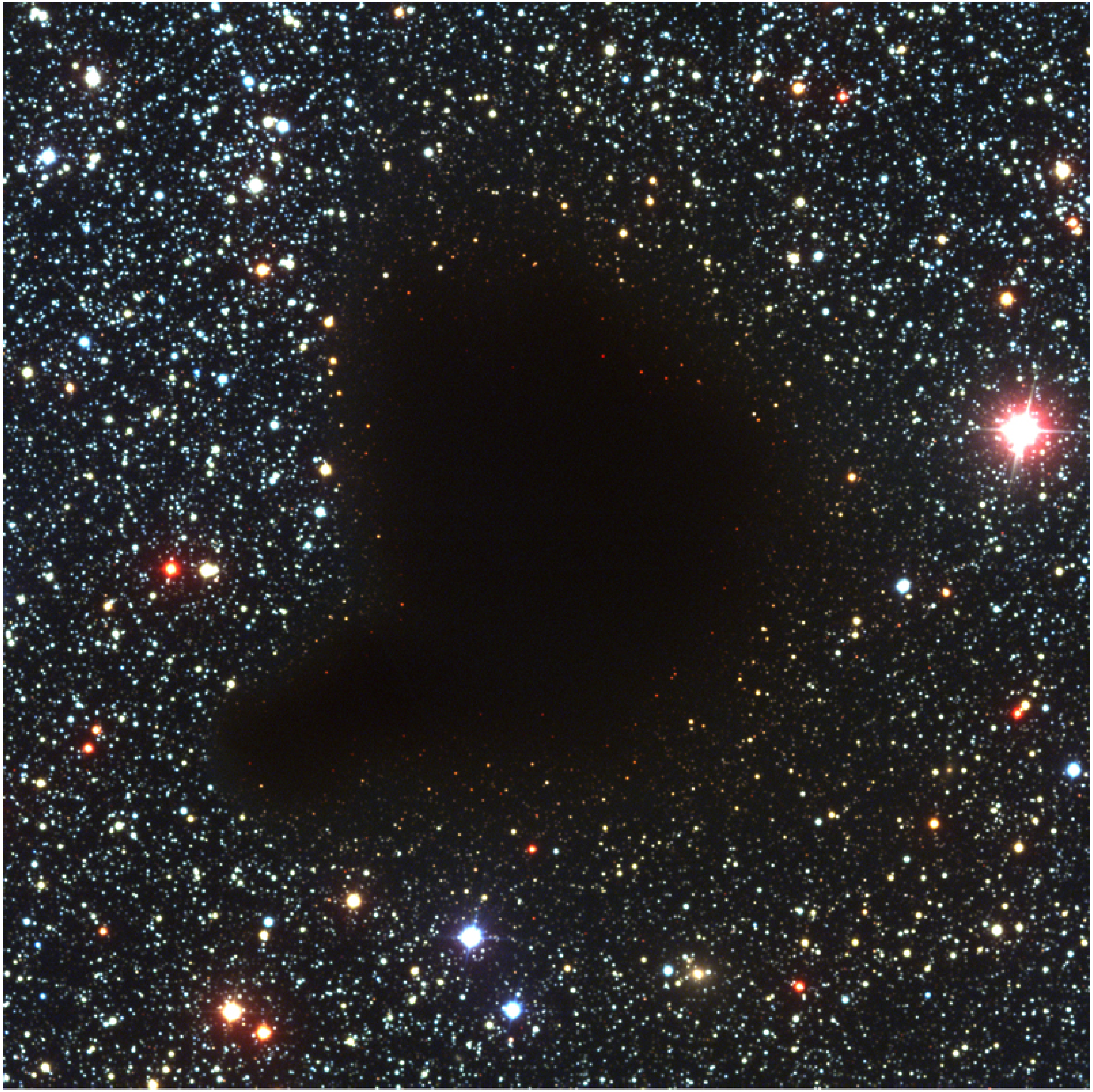
The real topic is star formation

A quick overview:

- Start out with a Giant Molecular Cloud.
- For some reason the cloud starts fragmenting and bits and pieces begin to collapse.
- Stars form within these blobs (see pep talk #2).
- Eventually the new born stars can blow away the remains of the cloud from which they formed.
- Later still, the stars disperse.

➔ Stars do not form in isolation!

➔ Interest in stellar clusters!



The "Black Cloud" B68
(VLT ANTU + FORS1)

ESO PR Photo 20a/99 (30 April 1999)

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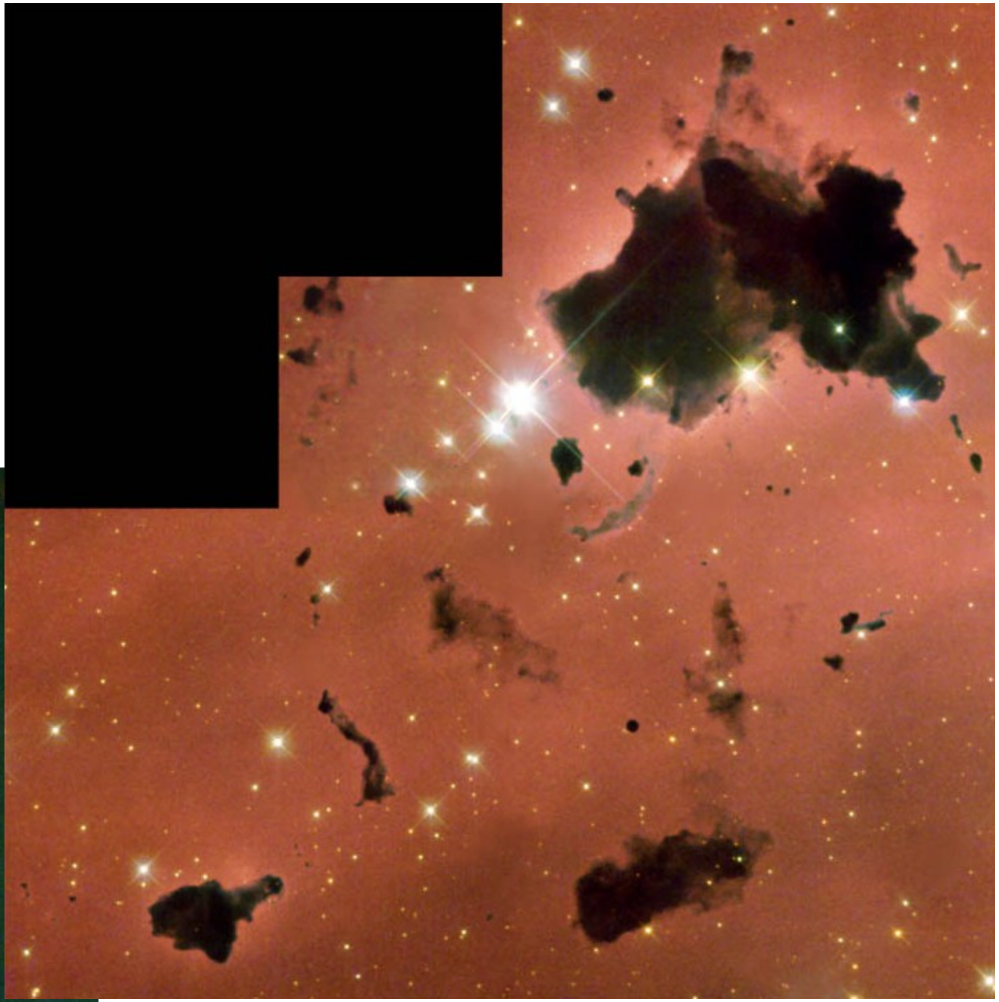

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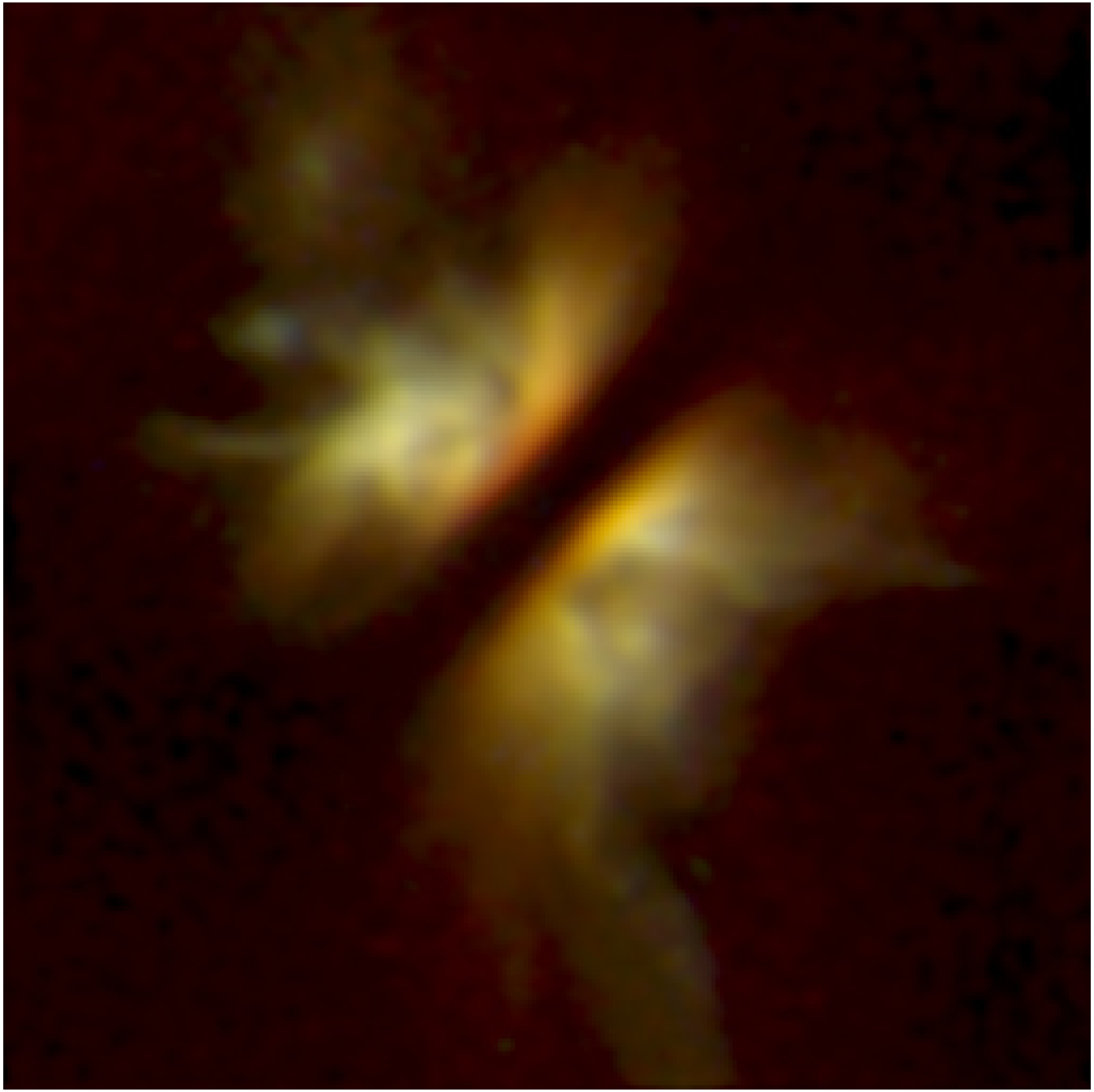

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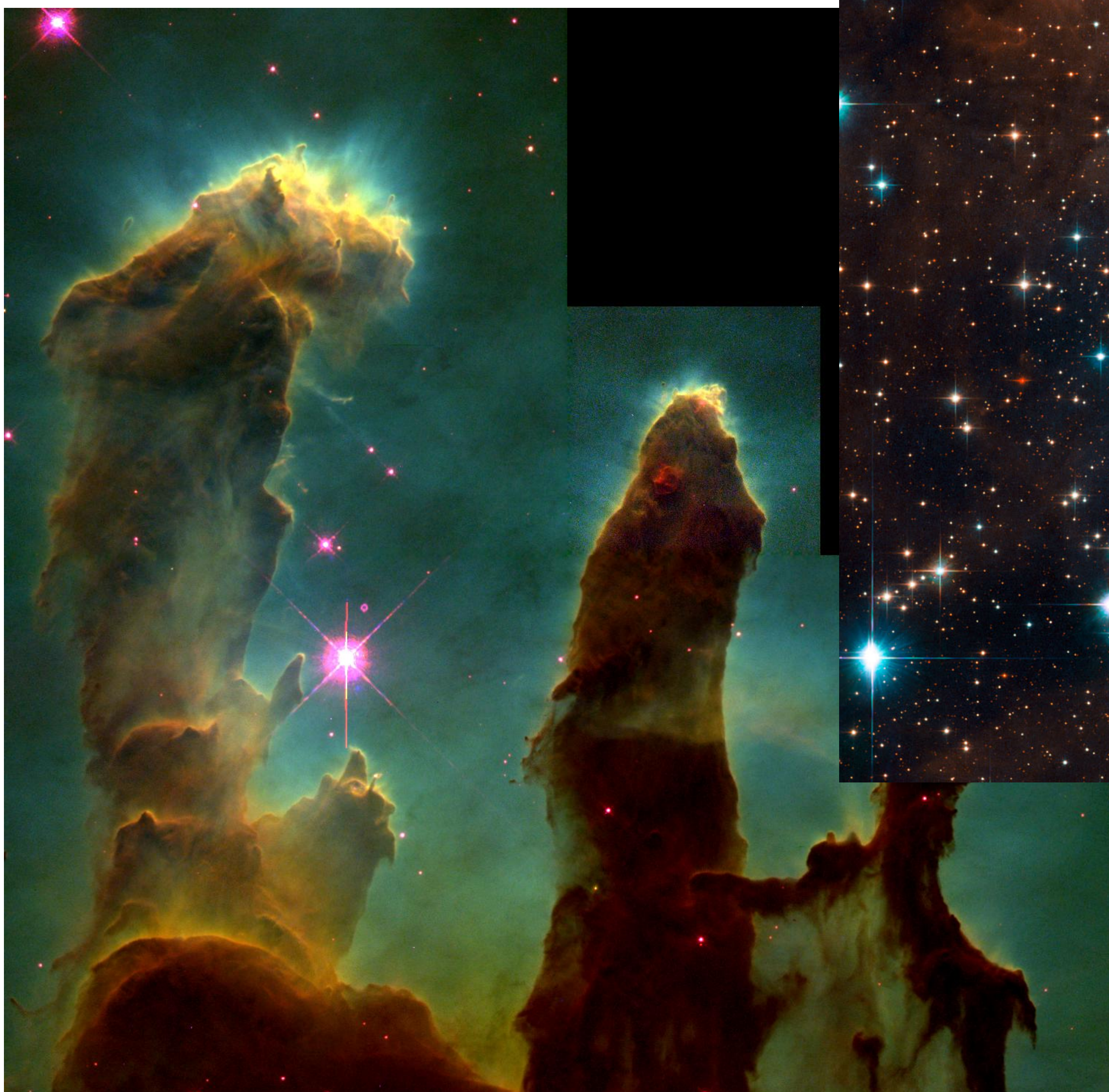

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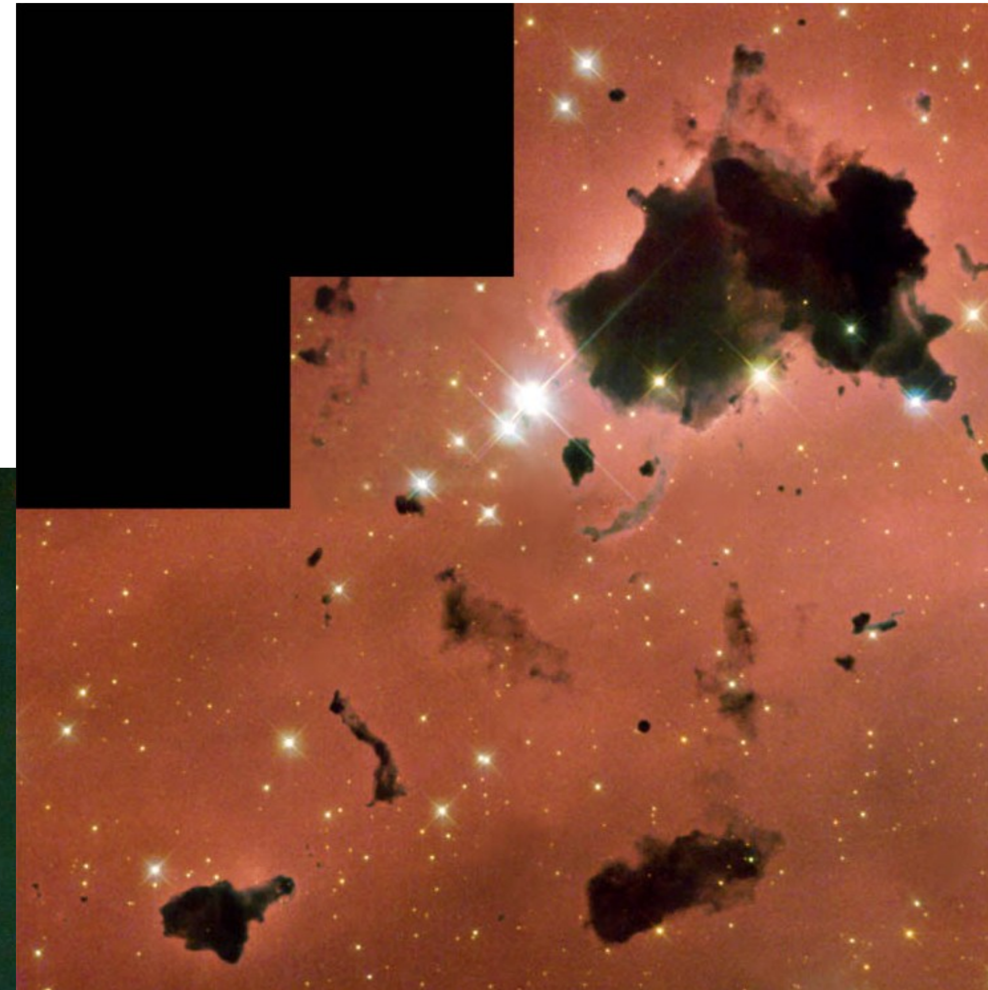
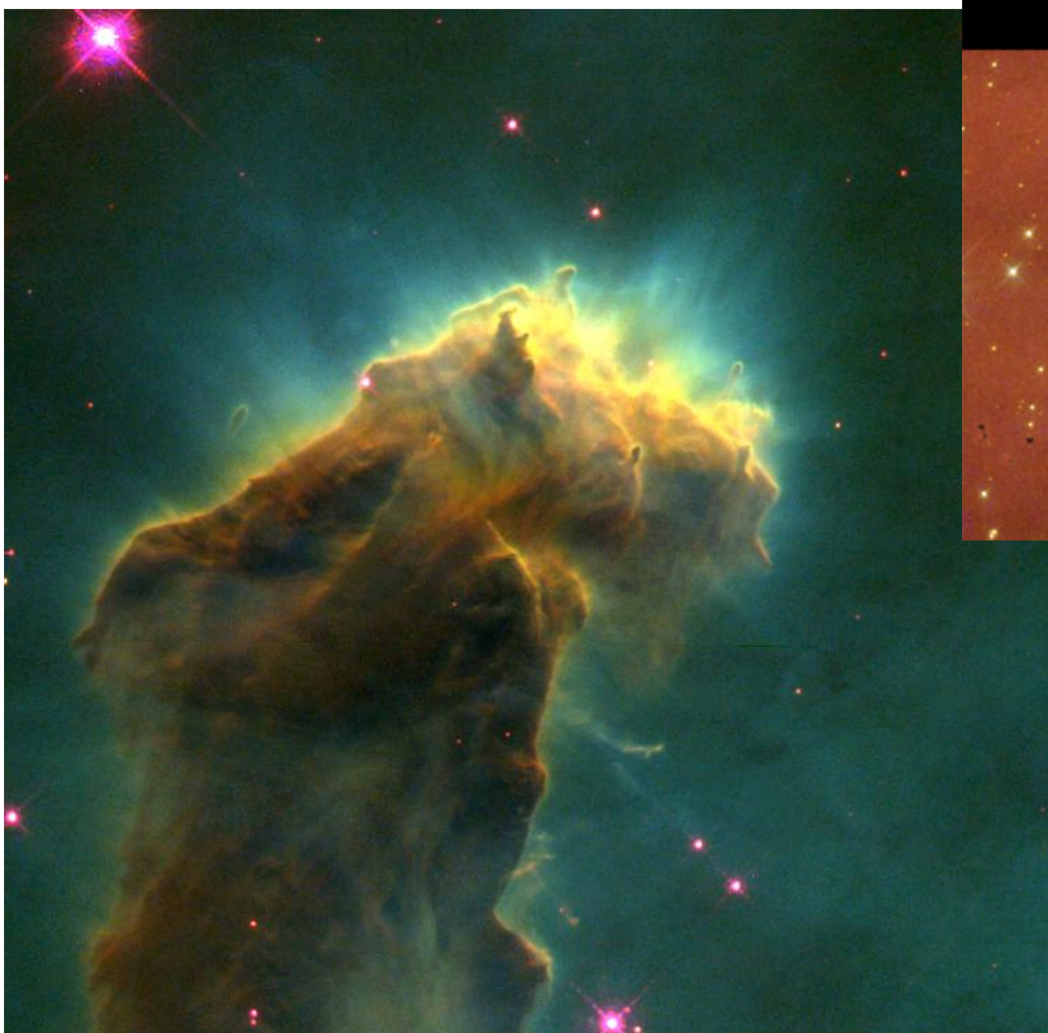
Question 1: massive star formation

- The most massive stars shouldn't be forming! They emit so much radiation early on that they should blow themselves apart!
- What's going on? Difficult to say!

Question 1: massive star formation

- The most massive stars shouldn't be forming! They emit so much radiation early on that they should blow themselves apart!
- What's going on? Difficult to say! The formation is going on inside the dark clouds!
- Need look in near and mid-IR where dust extinction is less severe.
- Still need to be able to see through extinction of factor 100 – 1 billion ($\sim 10^{80}$ in the optical).
- Need to be able to resolve dense clusters, binaries.

Question 1: massive star formation

We want to:

- Determine number density of stars in dense molecular cloud cores $\rightarrow$ likelihood of collisions.
- Check if clusters are mass segregated at birth.
- Find evidence for dynamical interactions from astrometric and radial velocity measurements.
- Determine the spectroscopic binary population at birth.
- Look for sub-fragmentation of a centrally-peaked, dense molecular core.

➔ Need near and mid-IR, LTAO imaging and IFU spectroscopy.

➔ Let's us decide between competing theories of massive star formation!

Question 2a: the low-mass end of the IMF

IMF = Initial Mass Function = Mass distribution of stars and sub-stellar objects in a cluster when it is born.

- Complete IMF, including its low-mass end, may be known in the nearest star forming regions by the time the E-ELT enters operations.
- However, in terms of physical properties the low-mass end of the IMF is uncharted territory. What are these objects like?
  - Atmospheres with complex chemistry.
  - Dust formation and disappearance.
  - Clouds and weather patterns.

Question 2a: the low-mass end of the IMF

- Need spectroscopy from red-optical to 3.5 um.
- Need to reach high S/N in < 2 hours (because of rotation).
- Want to monitor objects on various timescales.
- Need advanced theoretical models to understand these objects.

➔ Insight into a currently unknown type of object!

Question 2b: Is the IMF universal?

- Is the IMF the same in all environments and was it therefore the same at all times?
- Key parameter to consider: metallicity.
- But the metallicity in the solar neighbourhood is roughly constant.

➔ Need to go to the Magellanic Clouds: LMC has 40% of the solar metallicity, SMC has 15%.

- Comparison of IMFs is best done in at the low-mass end: most robust and most likely to depend on metallicity.

Question 2b: Is the IMF universal?

- Deep near-IR GLAO imaging of fields in the LMC and SMC will provide access to the IMF in these environments down to 0.2 M_{solar}.
- Comparison to the IMF in the solar neighbourhood will provide the first direct answer to the long-standing question regarding its universality.
- IMF is one of the most fundamental and important observational properties of the complex business of star-formation. It provides insight into the theory of star-formation and stellar evolution, and its knowledge is required for the interpretation of a plethora of observations in both galactic and extra-galactic astronomy.