Stellar Evolution:
from star birth to star death and back again

Prof. David Cohen

Dept. of Physics and Astronomy

This presentation is available at:
astro.swarthmore.edu/~cohen/presentations/admitted_students_2006/

General information: astro.swarthmore.edu/

We teach two **intro classes** (Astro 1 and Astro 3), plus the intro Physics class has a cosmology component

Two **intermediate** level classes

And four **seminars** for Juniors and Seniors

I will present some images from the Hubble Space Telescope of very young and very old stars, as well as the interstellar gas that connects them.

Some of this material is taken from one of our classes for non-majors: Astronomy 1: Introductory Astronomy (see astro.swarthmore.edu/astro1).

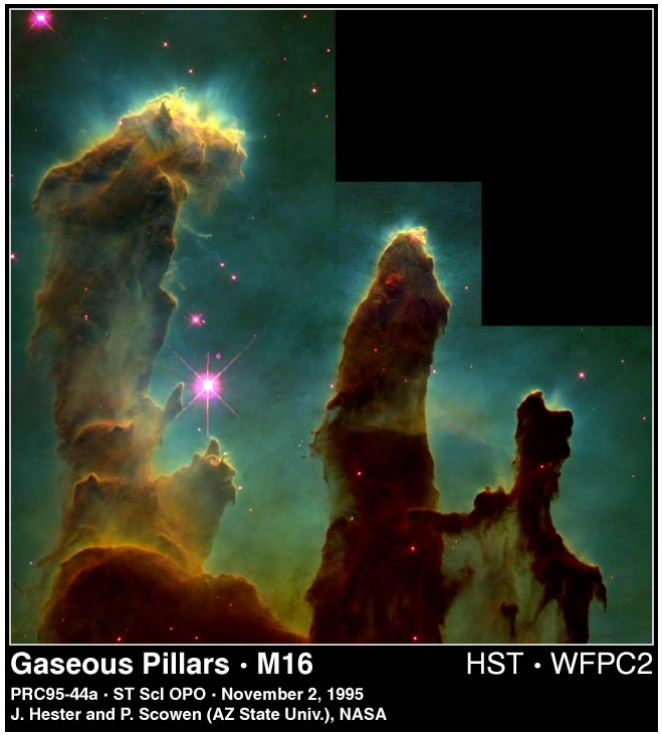
But connections will also be made to some of the research projects that Profs. Cohen and Jensen work on with their students.

The stars we see when we look up at night haven't been here forever.

Some of them are quite young, in fact, and others are candidates to explode as supernovae.

Stars are continually being born and dying in our galaxy, with the chemically enriched matter that is the byproduct of the fusion that powers the stars being ejected into space and seeding the gas clouds that collapse into the next generation of stars, planets, and possibly life.

New stars being formed in the Eagle Nebula



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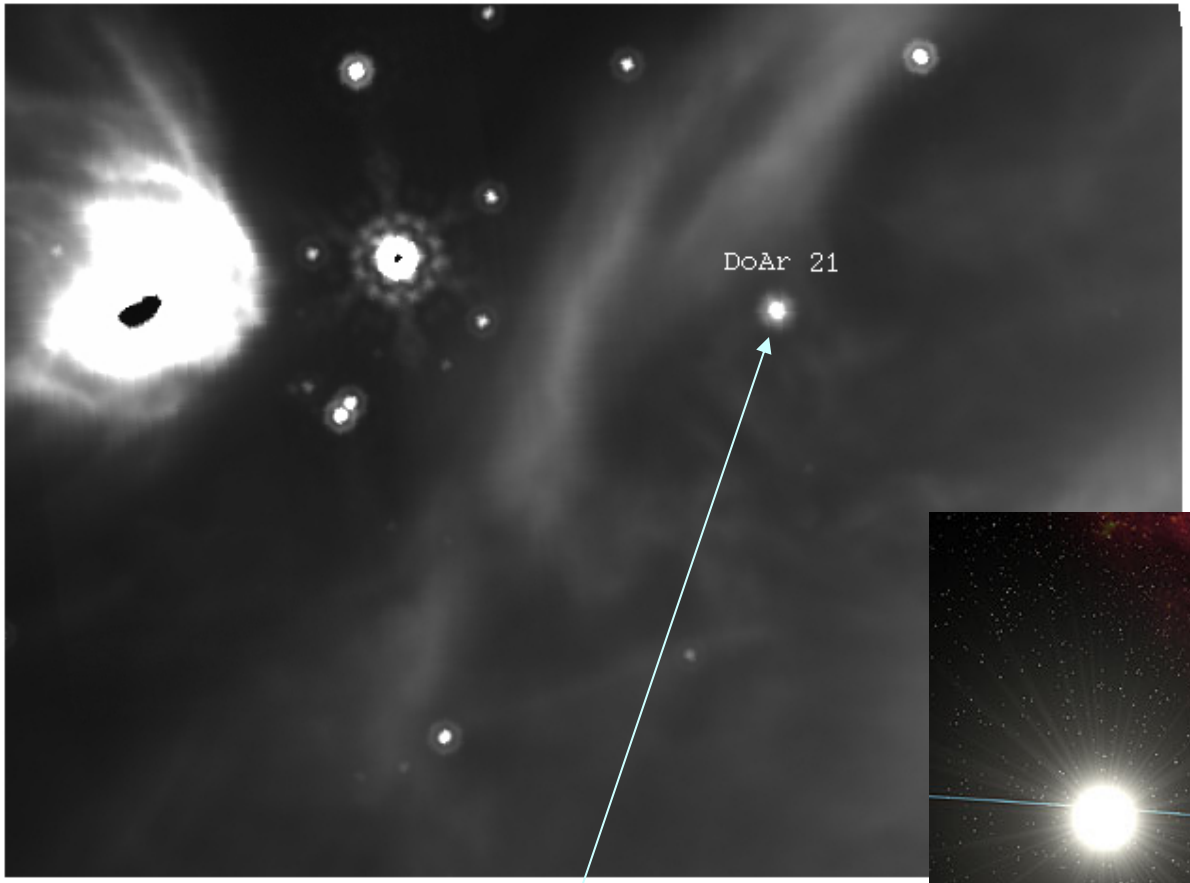
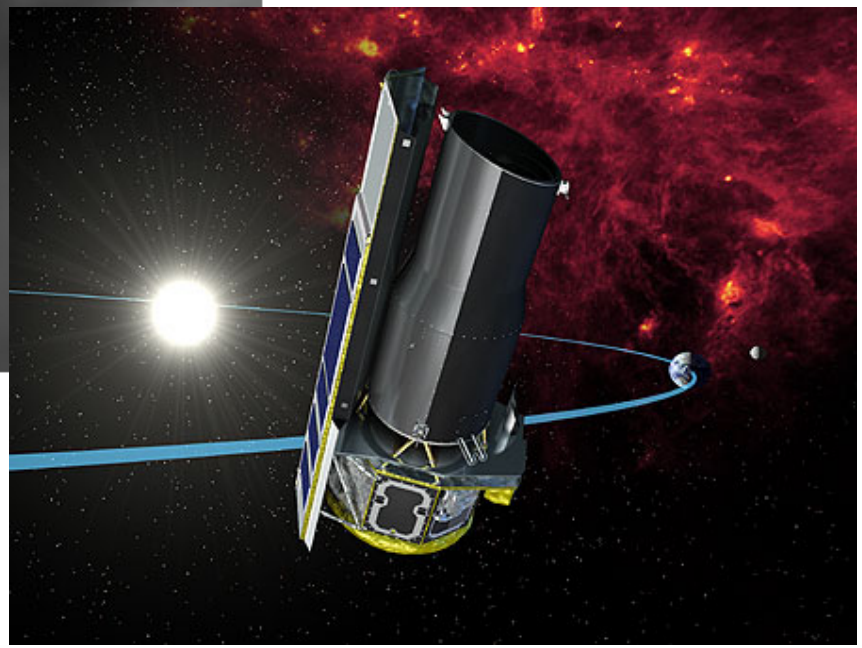
Hubble Space Telescope

Image of the rho Ophiucus star formation region taken with the Spitzer Infrared Telescope

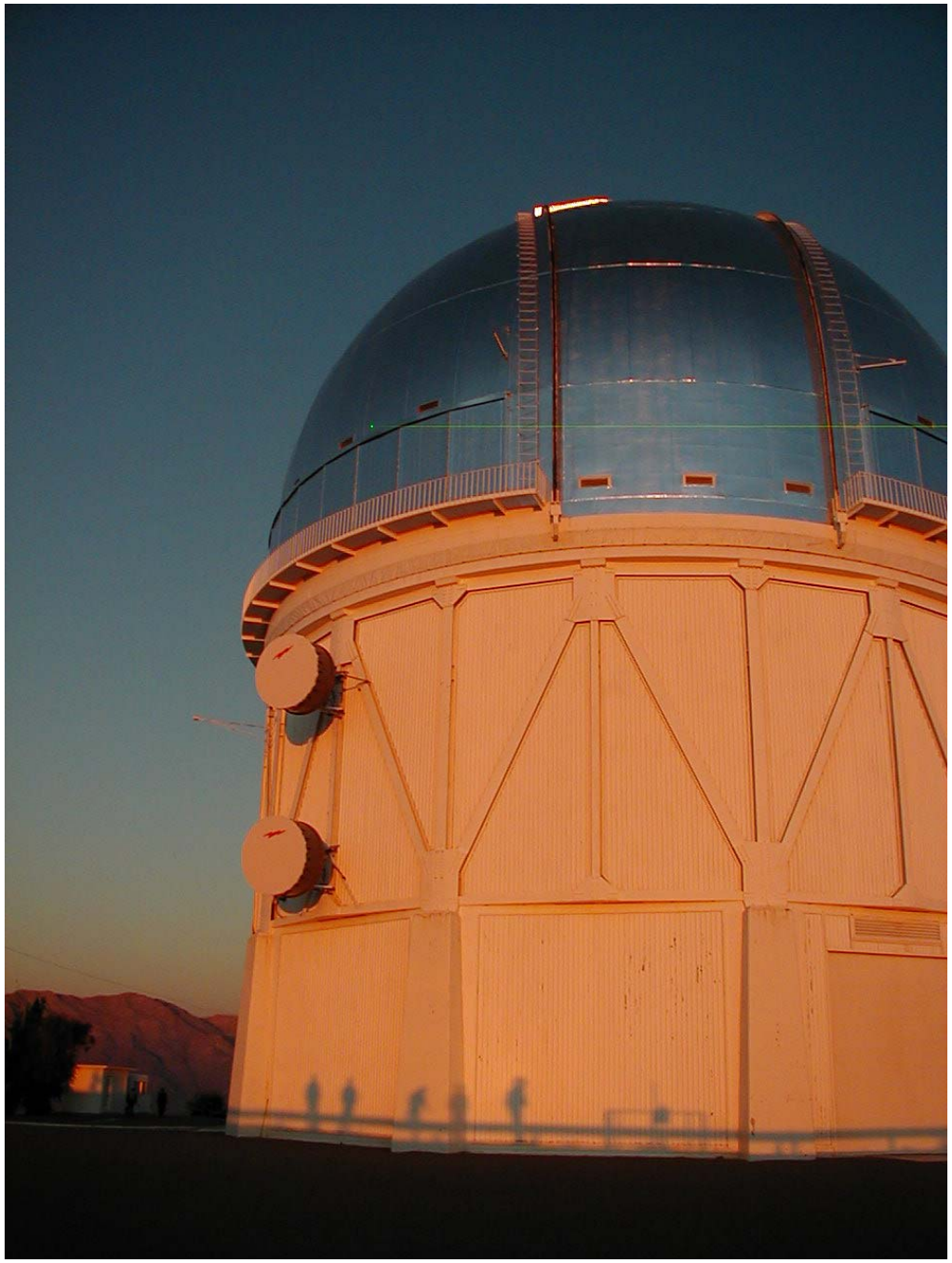


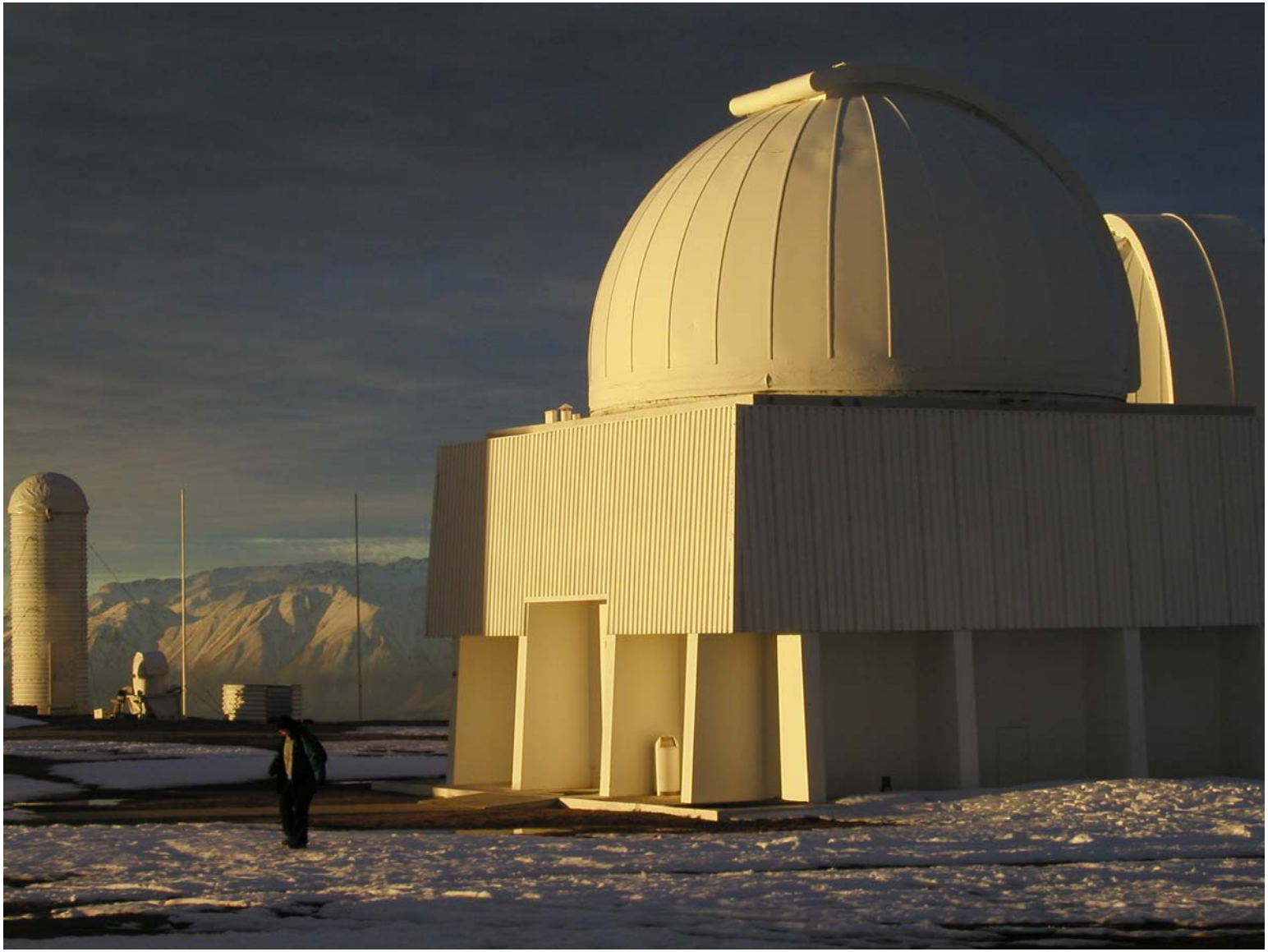


We are analyzing infrared, optical, and x-ray data from the young star, DoAr 21

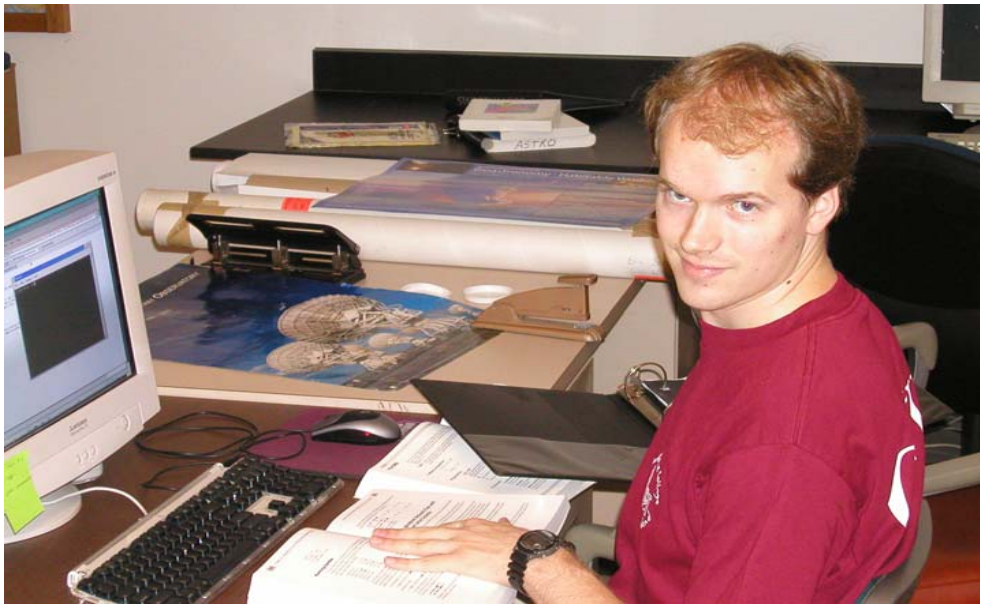
Research at Swarthmore involves our students

Allyn Dulligan (’02) at Cerro Tololo Intra-American Observatory in Chile (with Prof. Jensen)

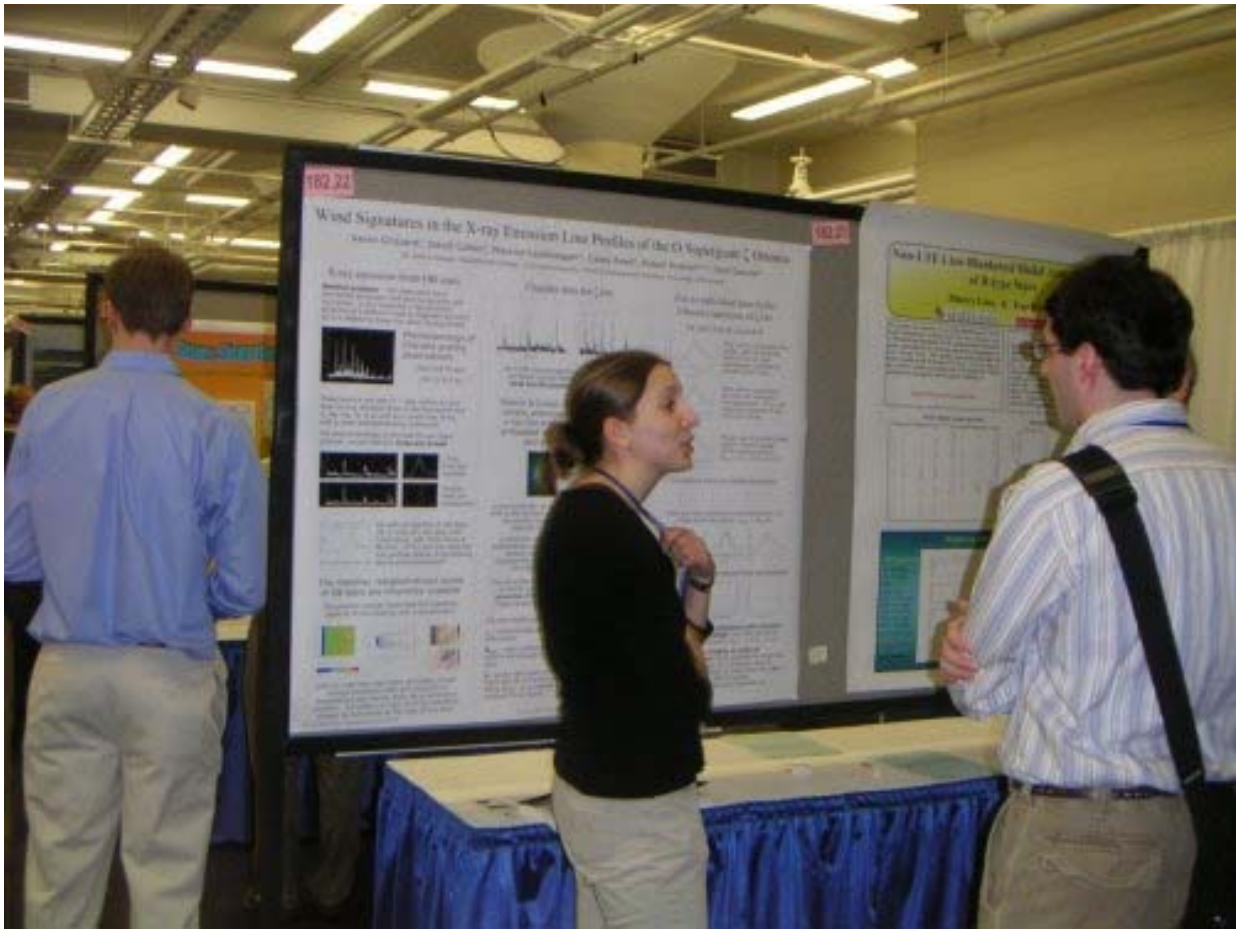




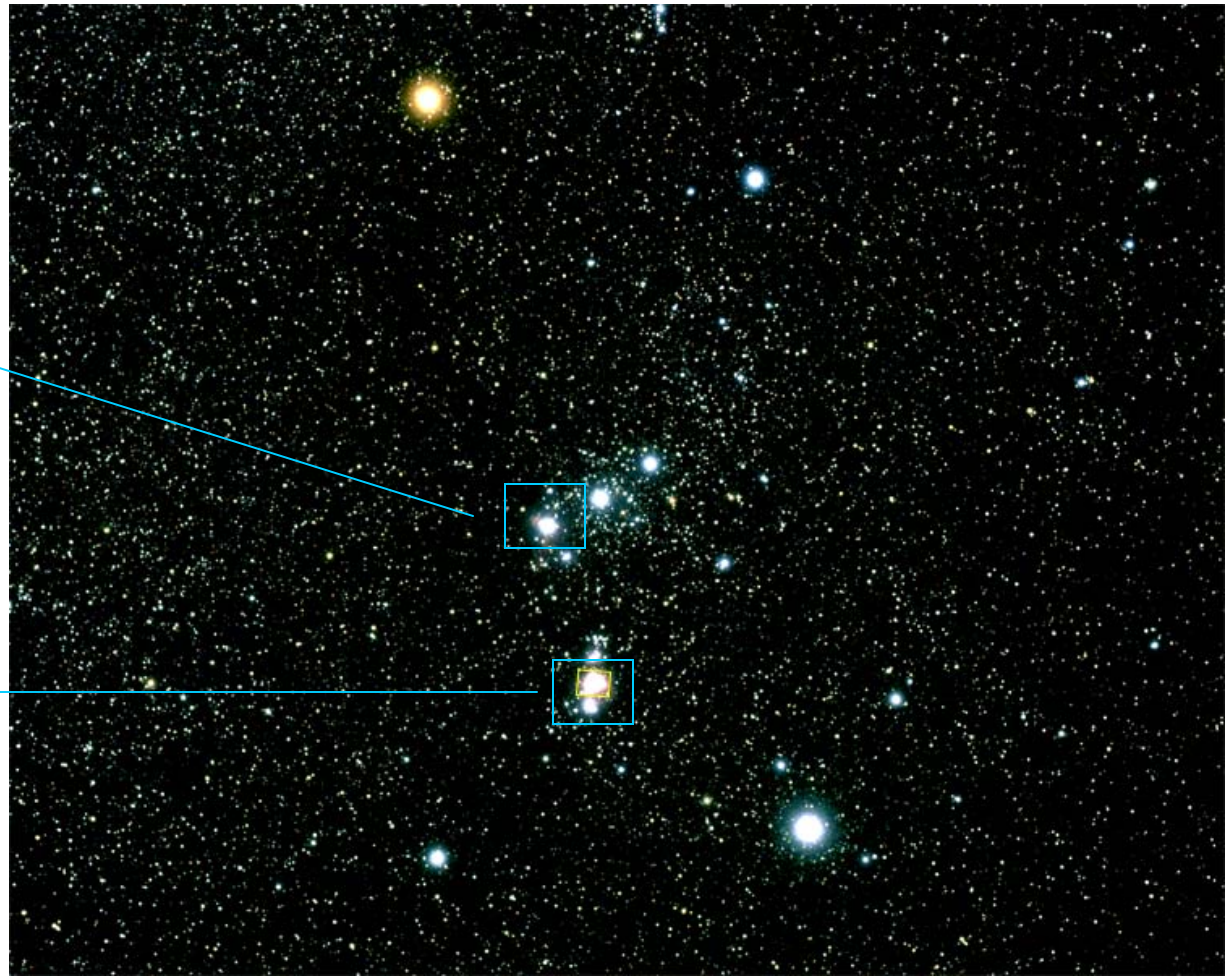
A more typical scene of student research!



Students present their research at national meetings – here the American Astronomical Society meeting in Washington, DC this past January.



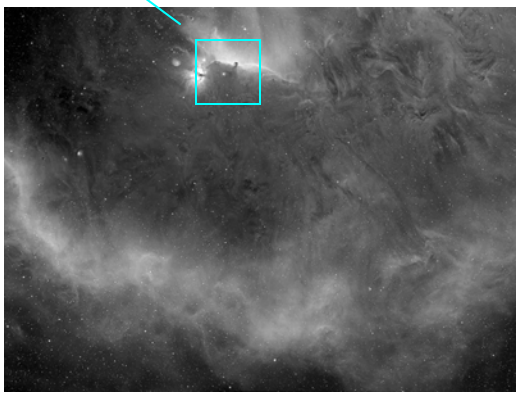
The constellation *Orion* is setting in the east, a little after sunset...Look down Parrish hill, toward the train station



The Great Nebula in Orion -- the red is hydrogen gas

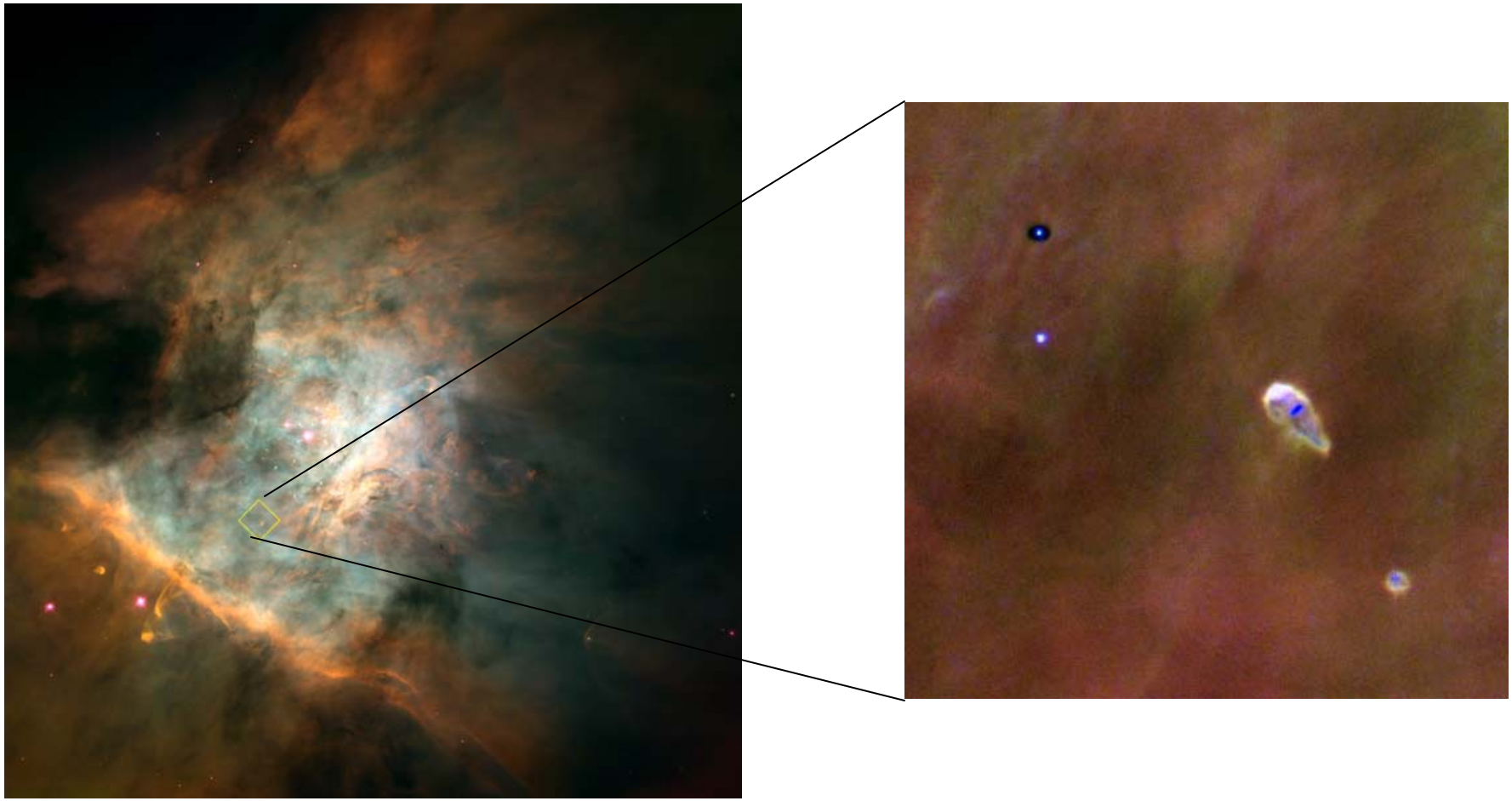
Image taken at one specific color - one specific spectral line - emitted by hydrogen

The Horsehead nebula in Orion...a pillar of dense gas and dust

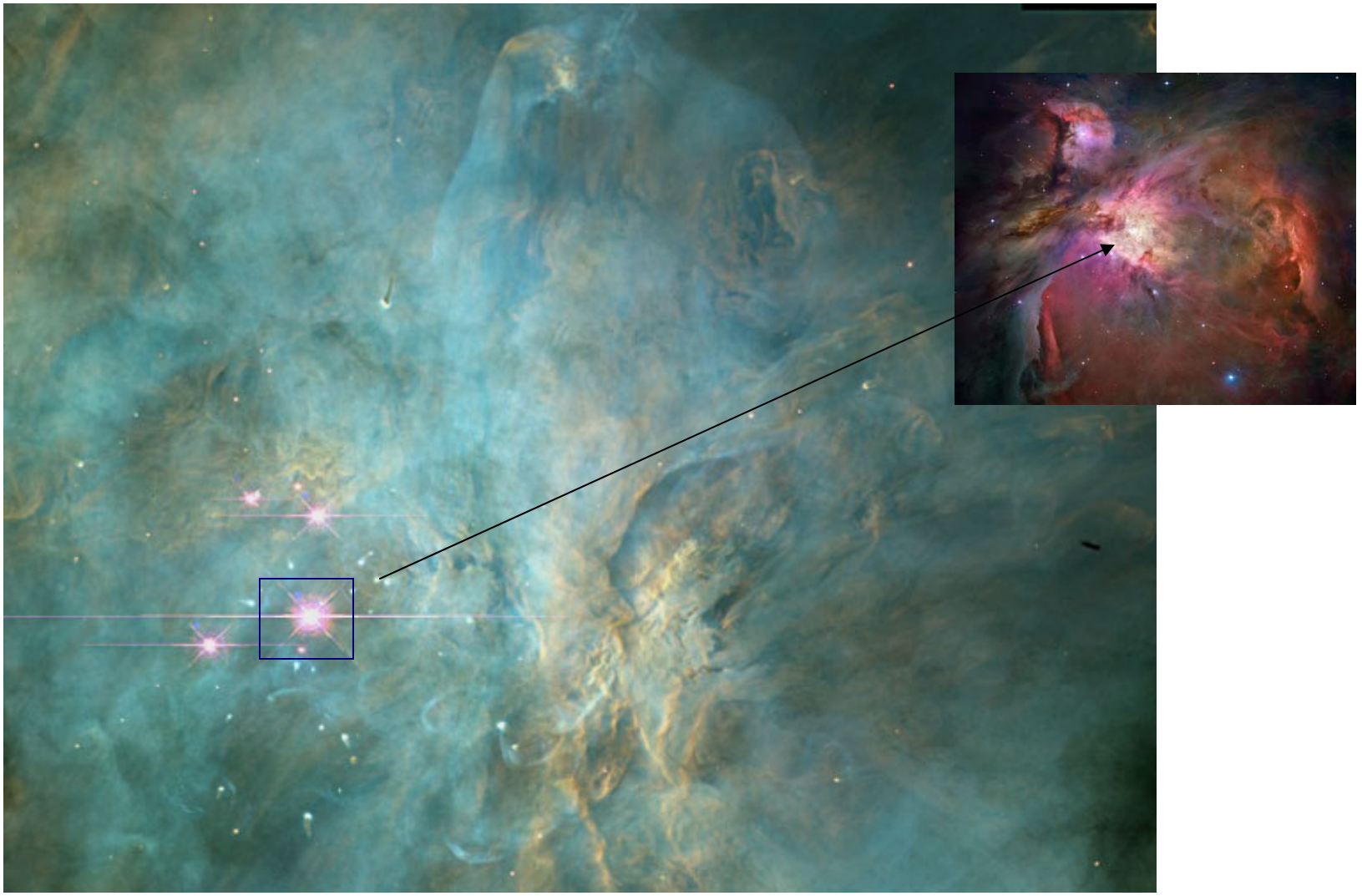


Another view of Orion; this one emphasizes the blue starlight reflected off of dust

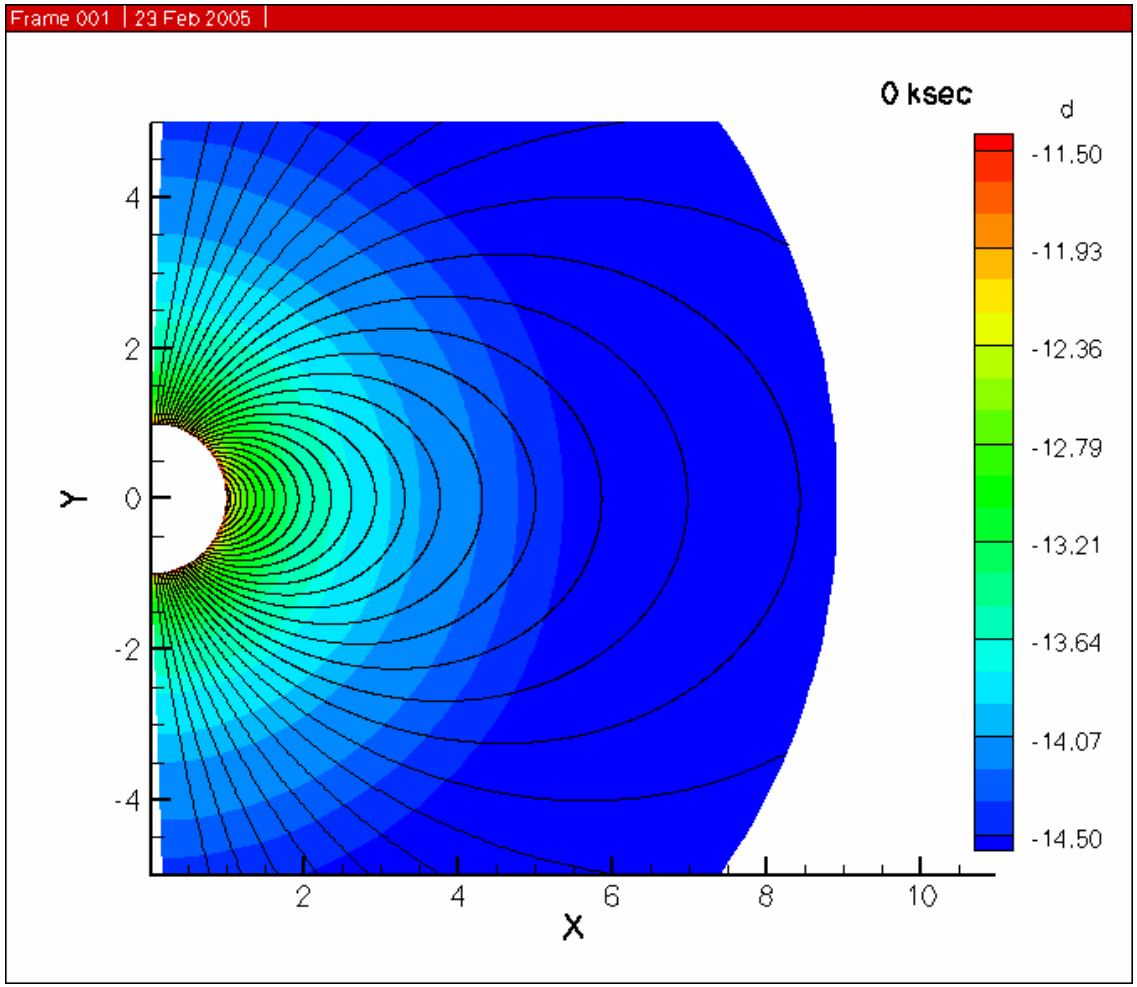
Young solar-systems forming in the Orion Nebula



A newly formed, very massive and luminous star - theta-1 Orionis C



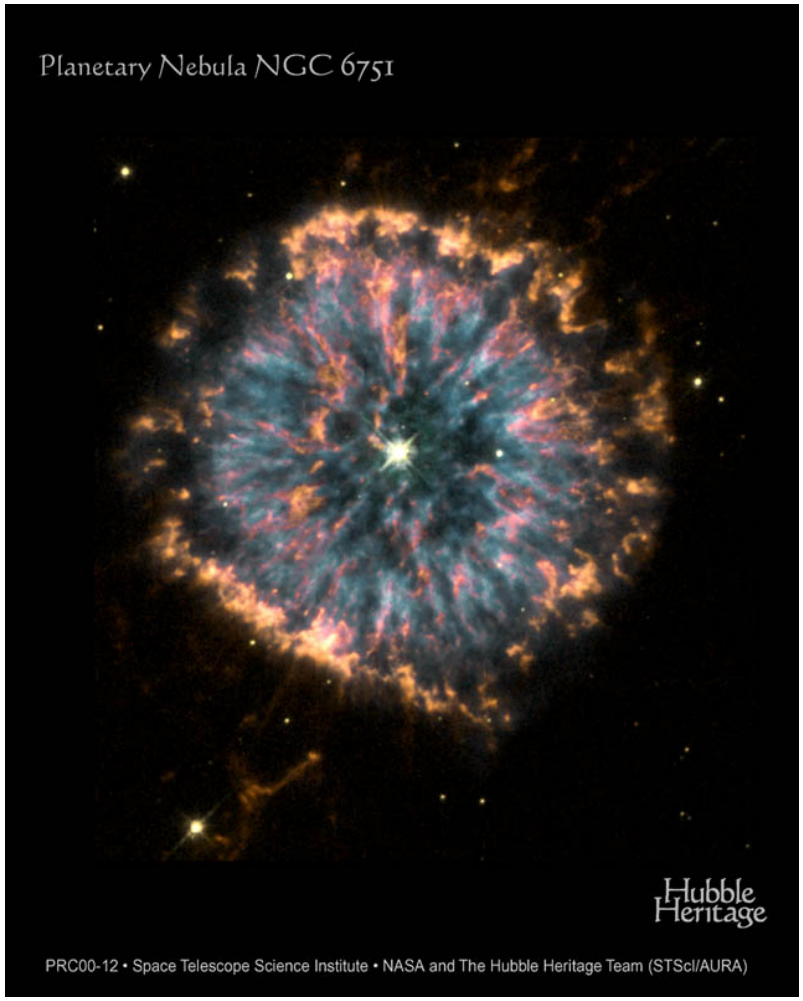
My students and I study the outflow of material from the surface of this young, massive star – its *stellar wind*



This numerical simulation shows the density of material in the magnetized stellar wind of theta-1 Ori C.

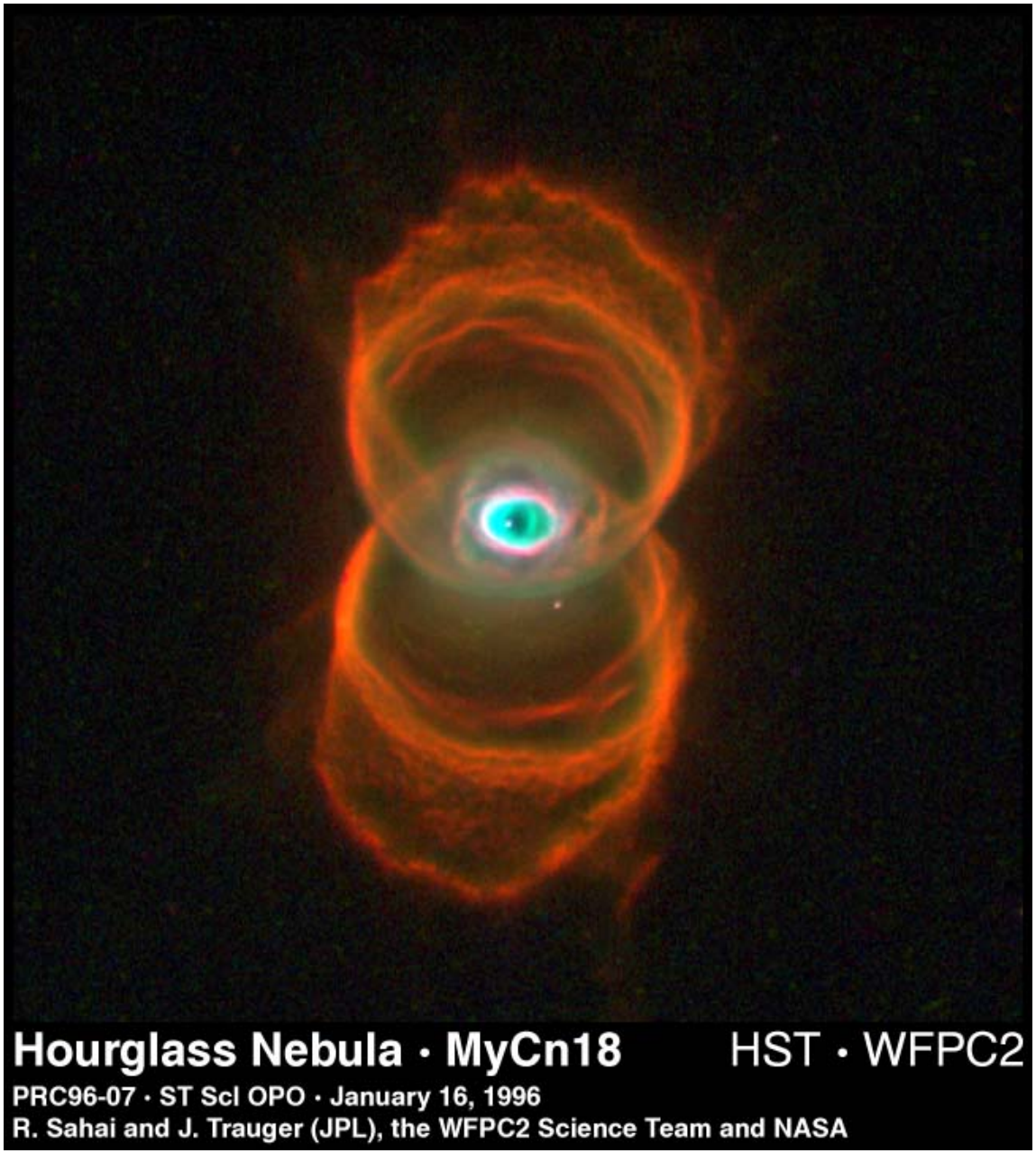
The belt stars of Orion – young hot stars, producing energy through the fusion of light elements into heavy ones

As stars age, they produce energy by fusion - fusing hydrogen to helium, and then helium to heavier elements (carbon, oxygen,... iron)

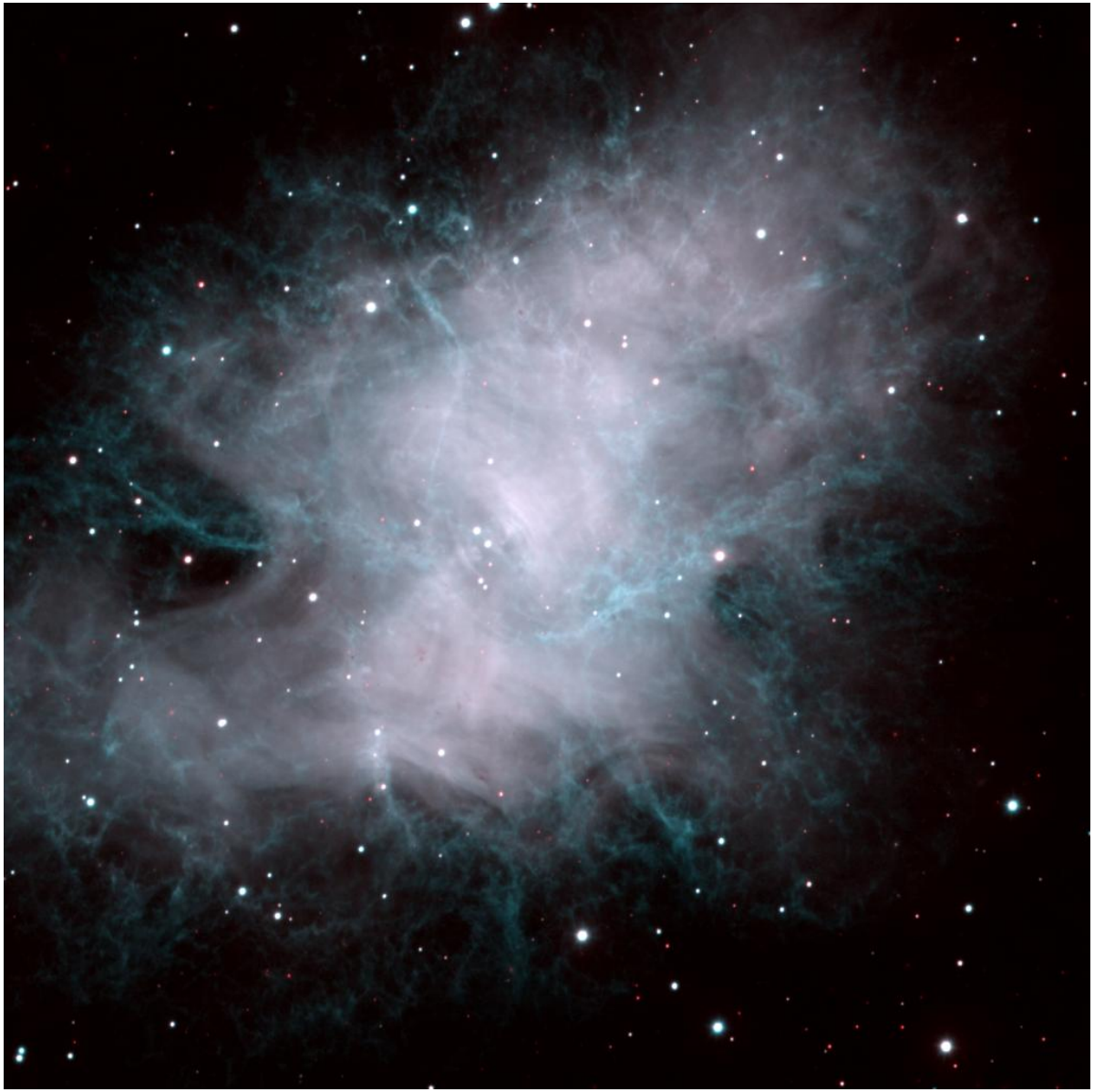


This “enriched” material is ejected back into interstellar space as the star is dying

Other planetary nebulae have more complex shapes



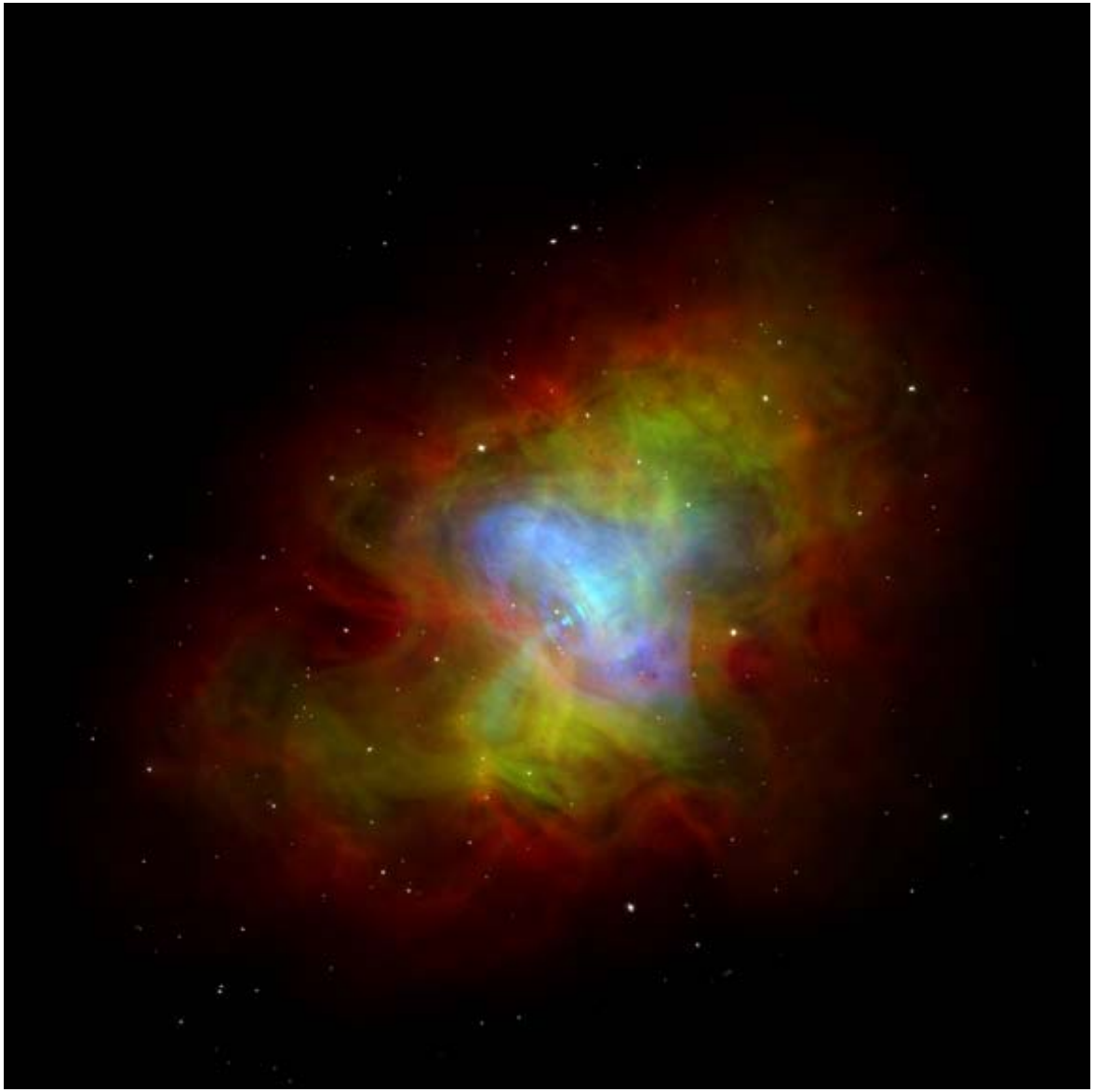
Some stars die even more violent deaths



The Crab Nebula was formed by a supernova explosion

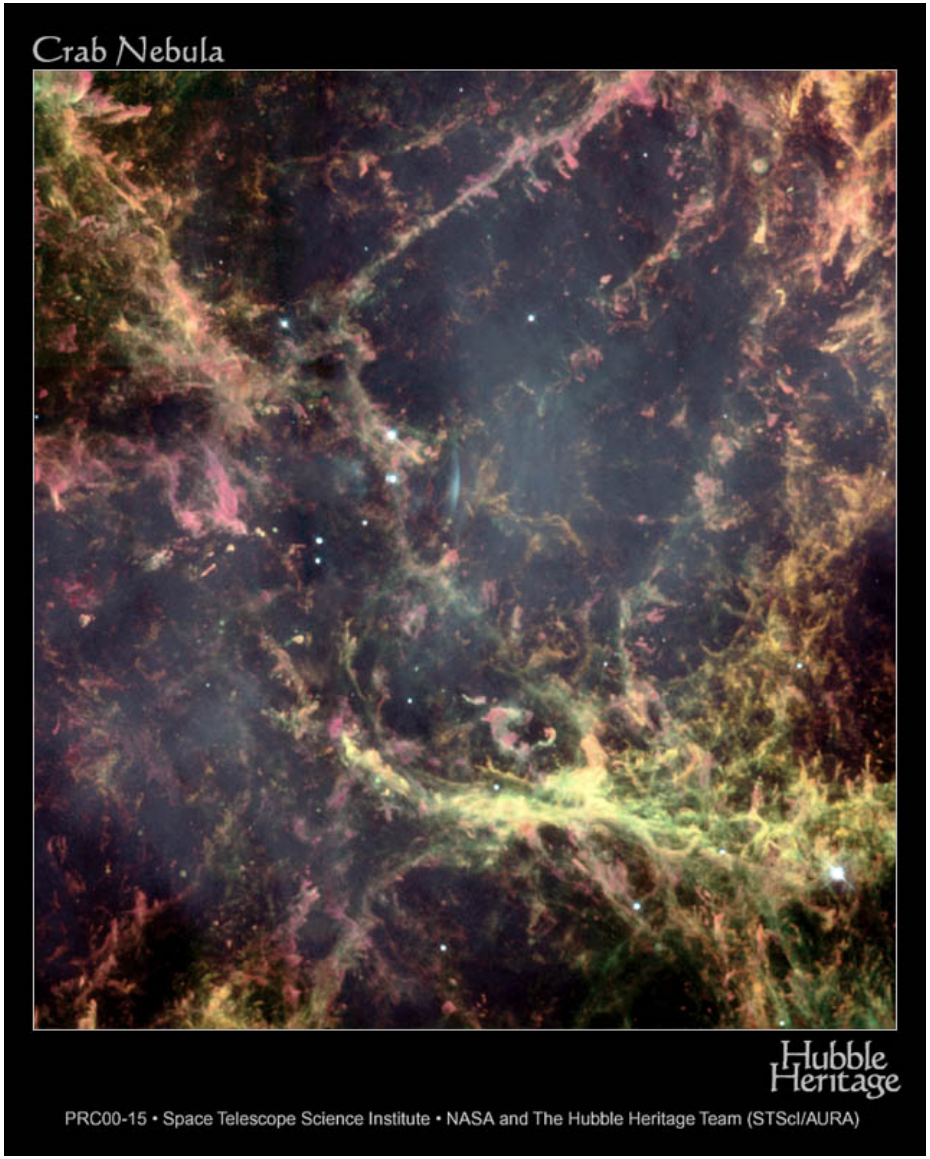
Combined optical (Hubble) and X-ray (Chandra) image of the Crab pulsar

Bigger view of Crab: Radio too



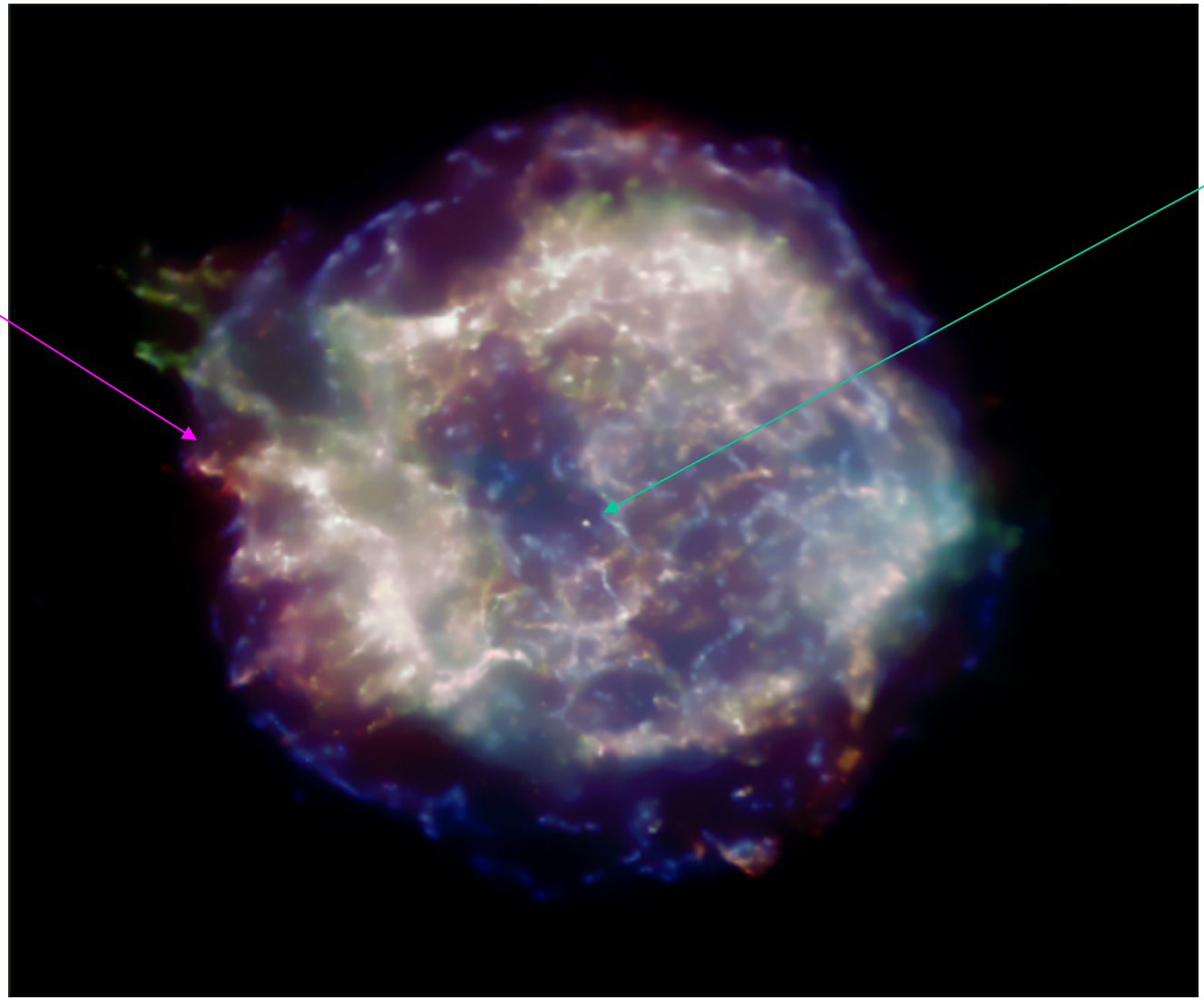
The Crab is expanding...what can we figure out from this observation?

Detail of Crab: Here the colors represent different elements.



X-ray image of the Cassiopeia A supernova remnant…different colors represent different wavelengths of X-ray ‘light’ which are caused by emission lines of different elements

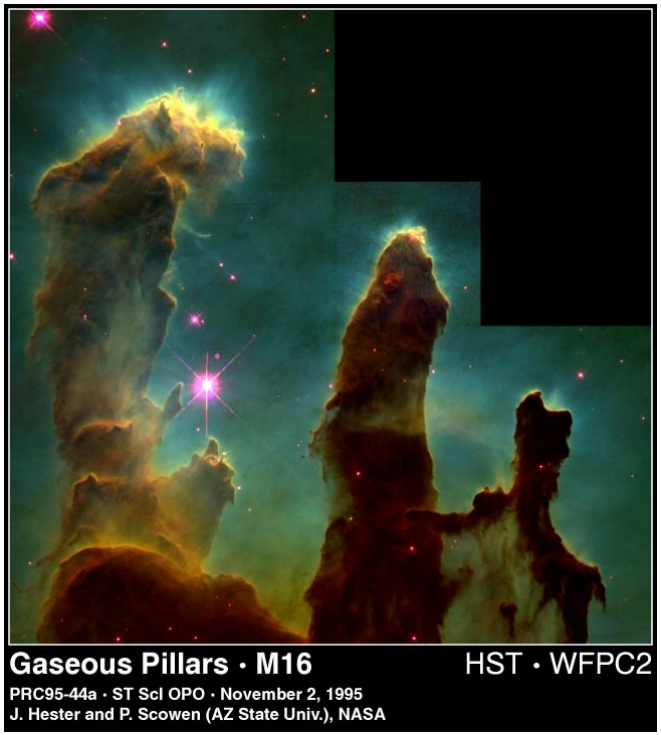
The red emission comes from *iron*…what’s it doing on the *outside* of the remnant?



Hot **neutron star** – the remnant of the core of the massive star that exploded in this supernova

Very old (10,000s years) supernova remnants fade back into interstellar space…enriching it with heavier elements

The energy and matter from these supernova explosions can initiate the collapse of nearby interstellar clouds…starting the process of star formation in a nearby location



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