

THE HELIX NEBULA
(NGC7293)

The Helix nebula

The Helix nebula is one of the best known planetary nebulae (PNs)

- Very near - 213 pc (Harris et al., 1997)
Large angular size (960 arcsec)
- Radius of 0.4 pc
- Evolved, old PN - dynamical age about 17000 yr (O'Dell & Burkert, 1998)
- Mass of ionized gas uncertain between 0.36 M_{\odot} (Young et al., 1999) and 0.074 M_{\odot} (Boffi & Stanghellini, 1994)
- Almost face-on - about 35° inclination
- Expansion velocity 31 Km/s (Meaburn et al., 1998)

The central star

One of the hotter and more massive central stars in PNs.

White dwarf, $T_{\text{eff}} = 117000 \text{ K}$ and $M = 0.93 M_{\odot}$ (Gorny et al., 1997)

It has been a massive star: enhanced He and N abundancies, C-rich PN (third dredge-up must have occurred)



The ionization structure

The structure is determined by the radiation from the hot central star

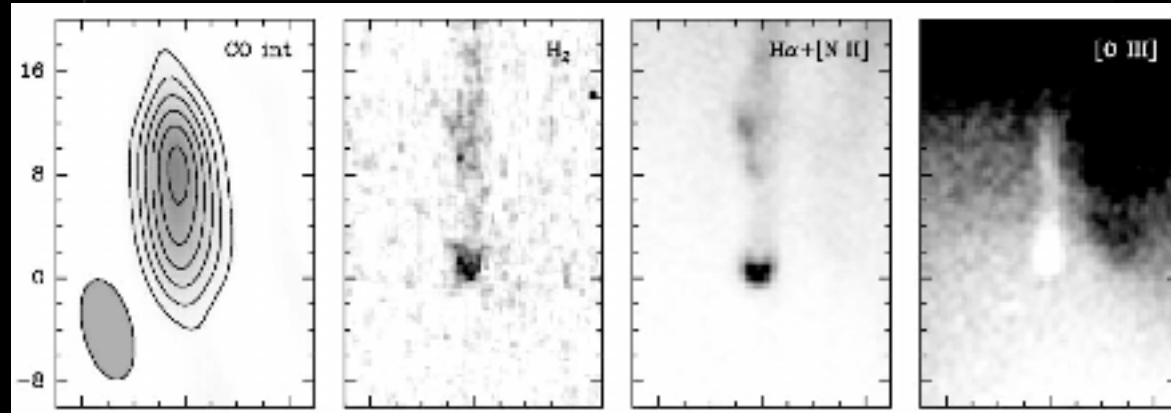
Dominant Ionic States	H^0, He^0 O^0, S^+	H^+, He^+ O^+, N^+	H^+, He^+ O^{++}	H^+, He^{++} O^{+++}
Primary Tracers	CO [OI] [SII]	[OII],[NII]	[OIII],HeI	HeII
Designation	H^0 IF	He^0	He^+	He^{++}

→
To central star

(O'Dell, 1998)

- H emission is observed in all the first four zones
- There is a sixth zone, with neutral H and molecules
- 3D structure, emission observed at any line-of-sight

The cometary knots



(Huggins et al., 2002)

dense condensation of molecular gas embedded in ionized gas

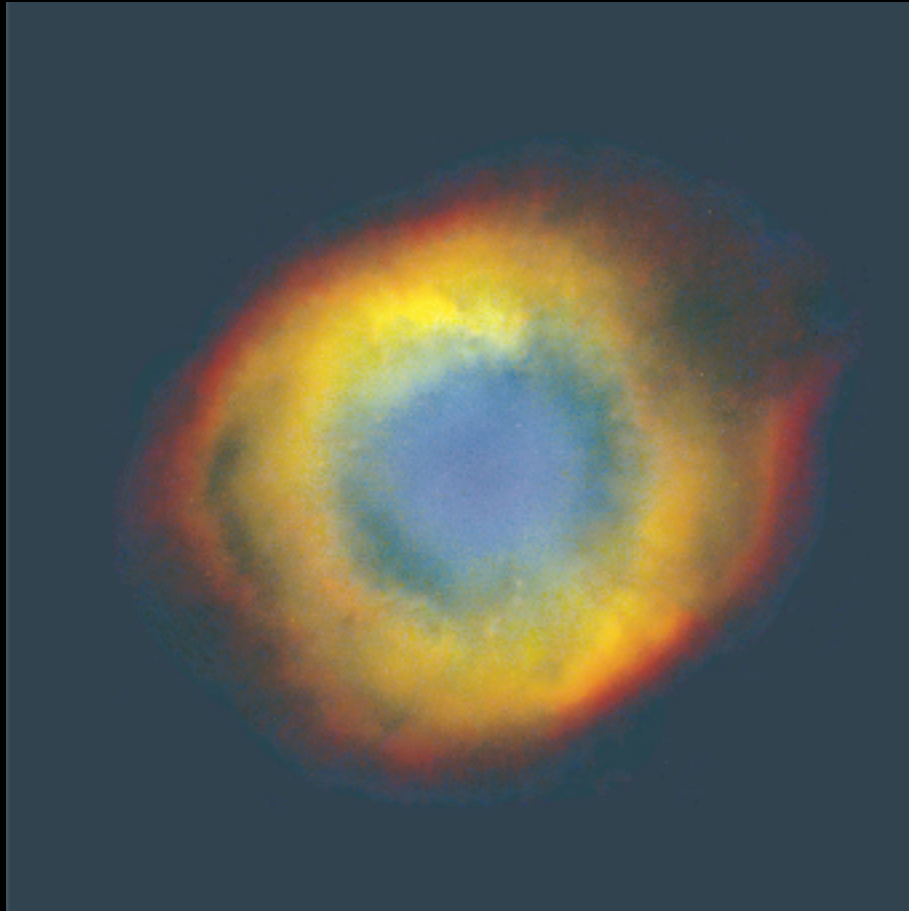
Found in lower ionization regions

Maybe common in PNs

Diameter about 0.001 pc (Dyson et al., 1989)

Estimated number: 3500 (O'Dell & Handron, 1996)

Optical observations



(O'Dell, 1998)

BLUE: HeII 4686 A

(4697 A filter, 196 FWHM)

YELLOW: [OIII] 5007 A

(5019 A filter, 50 FWHM)

RED: H beta

(4876 A filter, 25 FWHM)

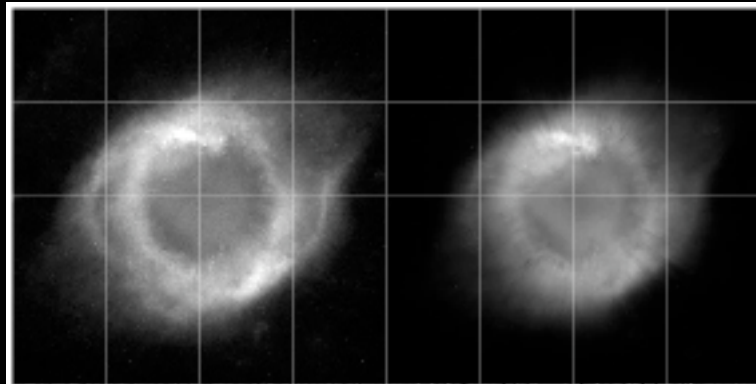
He⁺⁺ zone: blue

He⁺ zone: yellow

He⁰ zone: red

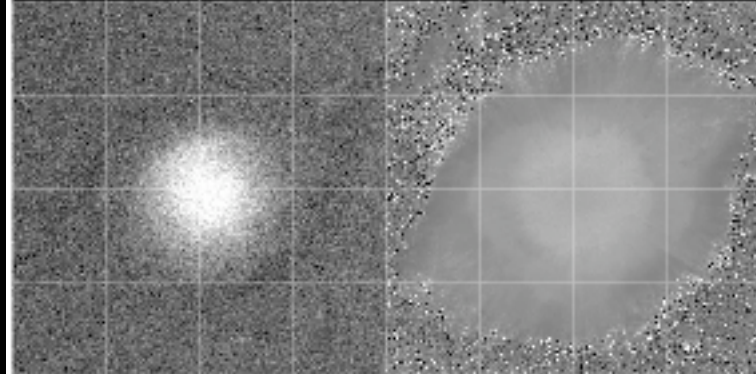
Red includes emission from all the regions, but weighted toward low T_e regions

H_{β}



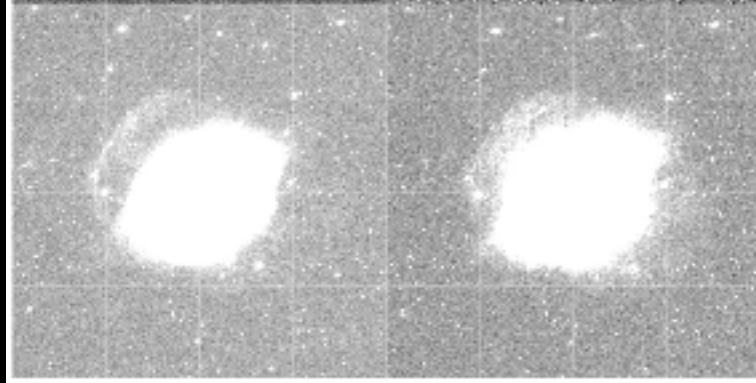
[OIII]

$H\alpha$



$\frac{[OIII]}{H_{\beta}}$

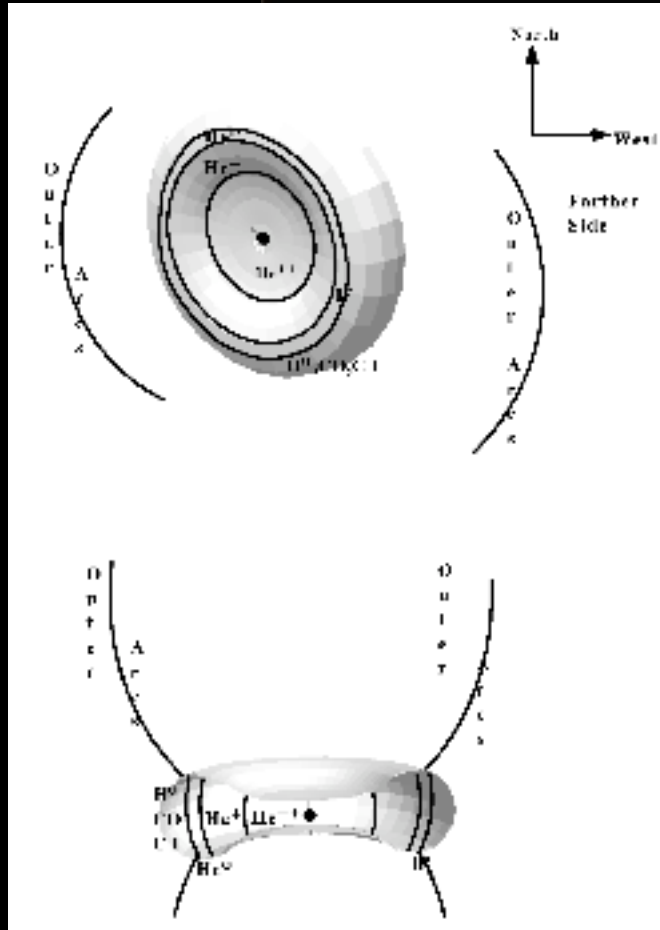
H_{β}



[OIII]

(O'Dell, 1998)

Some results from images and spectroscopy (O'Dell, 1998)



- “The ring is actually a disk”

In central region abundant heavy elements are highly ionized and have no important optical lines, but density is about the same ($N(H)$ around 60 cm^{-3})

- Large variation of T_e
(from over 20000 K in the inner region to 9200 K in He^0 zone)

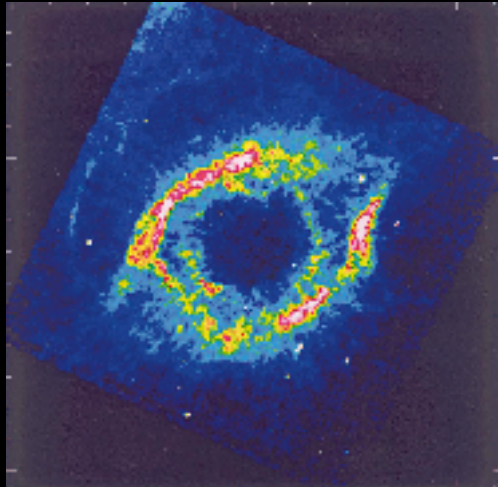
Needed to explain the variation of the H α -H β ratio and the He/H abundance increasing outward

IR observations (Cox et al., 1998)

5-8.5 micrometers

similar to the optical [OI] emission

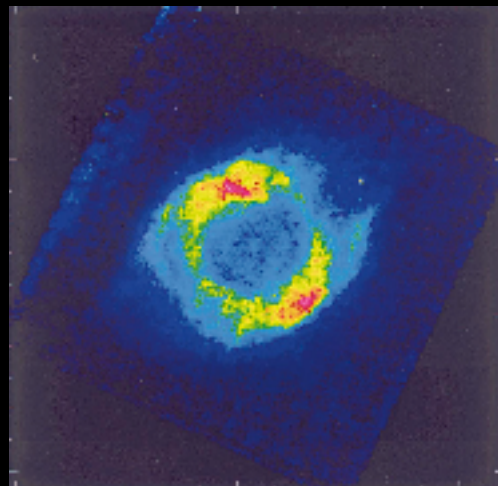
In this spectral region the nebula shows only H₂ rotational lines



12-18 micrometers

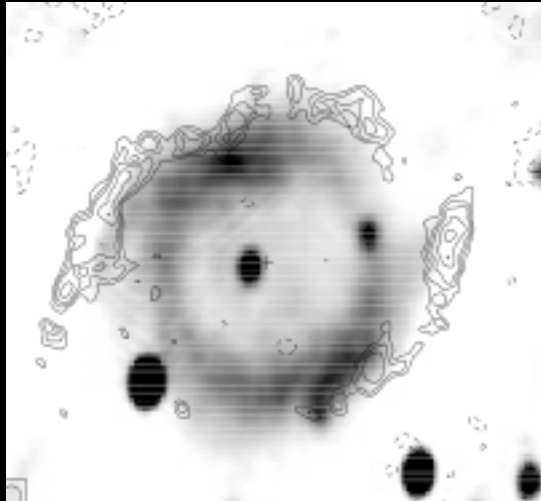
similar to the optical [OIII] emission

This spectral region is dominated by the [NeIII] emission line

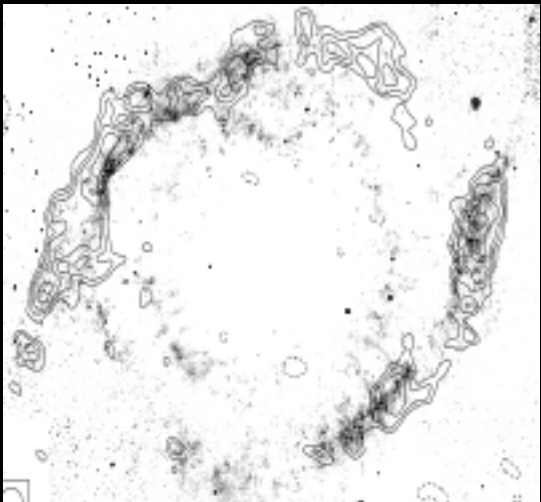


In IR spectra even weak [NeII] and [ArIII] lines are seen. The nebula is C-rich, but NO DUST bands are detected: small grains have been destroyed

HI maps



Free-free continuum emission in inner regions
HI 21-cm emission in the outer regions

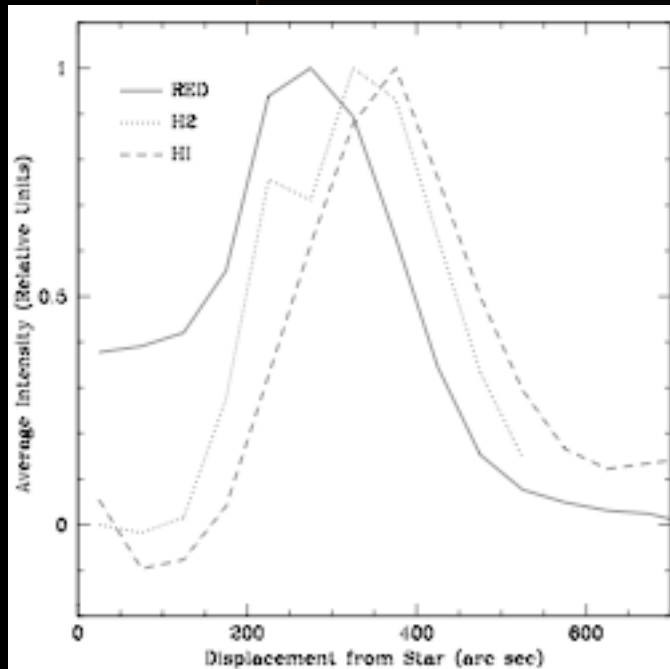


Great similarity with H₂ maps

Estimated HI mass: 0.07 M_o

(Rodriguez et al., 2002 and Speck et al., 2002)

large-scale stratification and coexistence of species



Molecules (CO and H₂) are not observed in the center, but are detected in inner regions containing cometary knots

HI is absent

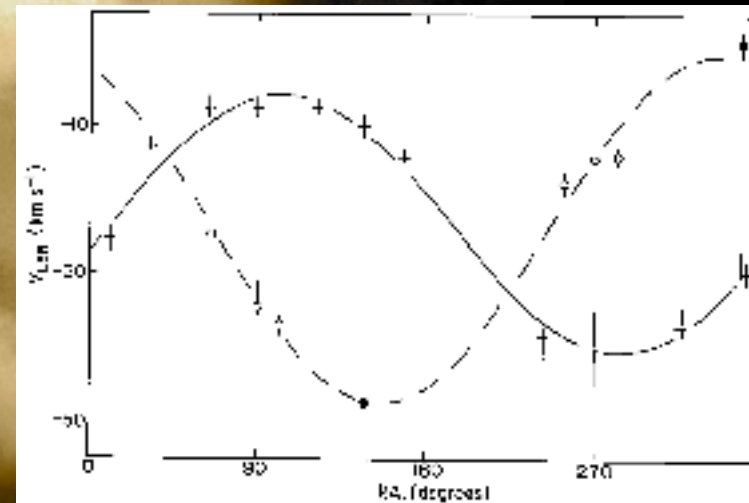
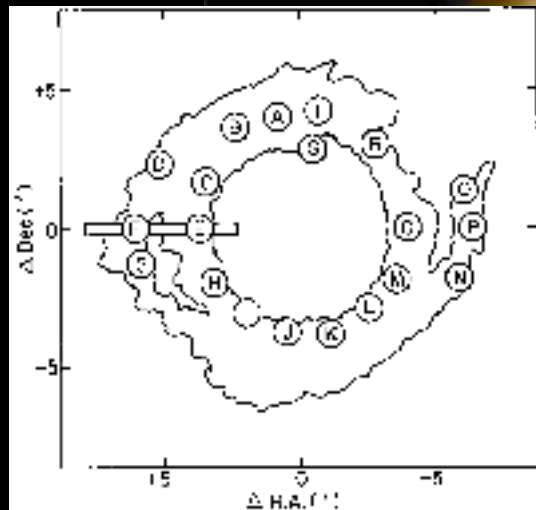
Model: inhomogeneous envelope partially destroyed by photoevaporation of original globules

CO observations

CO detected with structure similar to H₂

Estimated total CO mass: 0.03 M_⊙ (Huggins & Healy, 1986)

Estimated total molecular mass: 0.025 M_⊙ (Young et al., 1999)



(Huggins & Healy 1986)

Two distinct kinematics components: two expanding disks

References

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