Near-IR Survey of Low-Ionization Structures in PNe
–Proposal–

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Why search for H2 in PNe?

PNe emit throughout the elect. spectrum, but near-IR has many advantages:

In general:

- PNe contain substantial quantity of dust probably formed during the AGB stage of the central star;
- The near-IR provides lower attenuation to important dense regions than the visible;
- The atmospheric seeing at NIR is typically reduced compared to that of visible.

In particular:

- The mechanisms of excitation of the H2 emission in PNe are low-velocity shocks or UV pumped IR fluorescence;
- To decide between the above two excitation mechanisms a spatially resolved spectroscopic analysis of the H2 line spectrum is needed;
- Even if the exc. mechanism cannot be determined, the presence of H2 is important to understand how PNe evolve through wind interactions and photodissociation.

Why search for H2 in PNe?

- There are many emission lines in the range 1–2.5μm:
  - mainly the recombination lines of HI
  - vibrationally excited lines H2
  - atomic lines of He and [Fe II]
  - emission from other molecular species (Co and C_2)

➡ **Diagnostic tools to prove physical conditions inside the nebula**

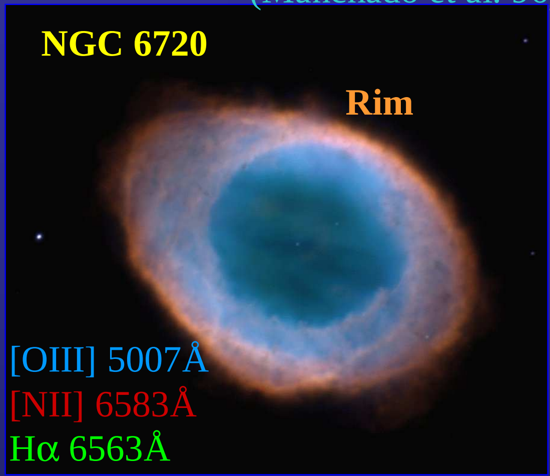
➡ **Sampling different regions and ranges of T, N, and excitation than is seen by optical emission lines!**

H2 emission associated with both
•high-density clumps
•low-velocity shocks

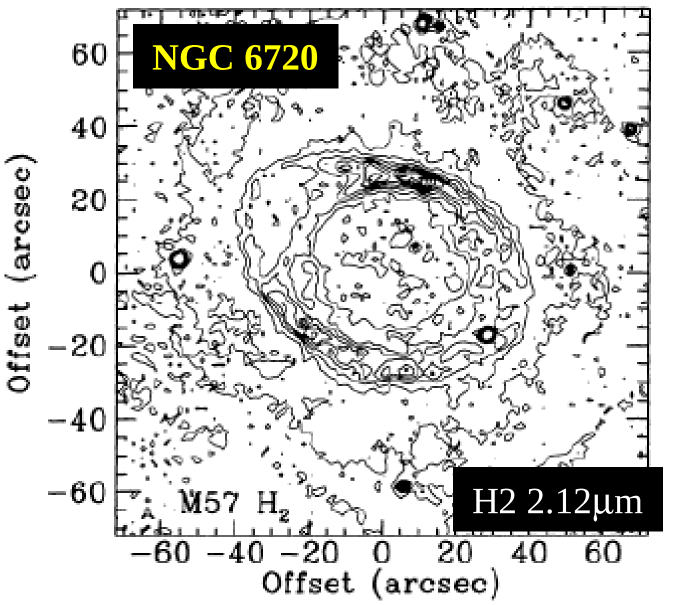
➡ is seen as a thin layer of warm H2.

H2 in PNe: NGC 6720 "Ring Nebula"

(Manchado et al. 96)



(Latter et al. 95)

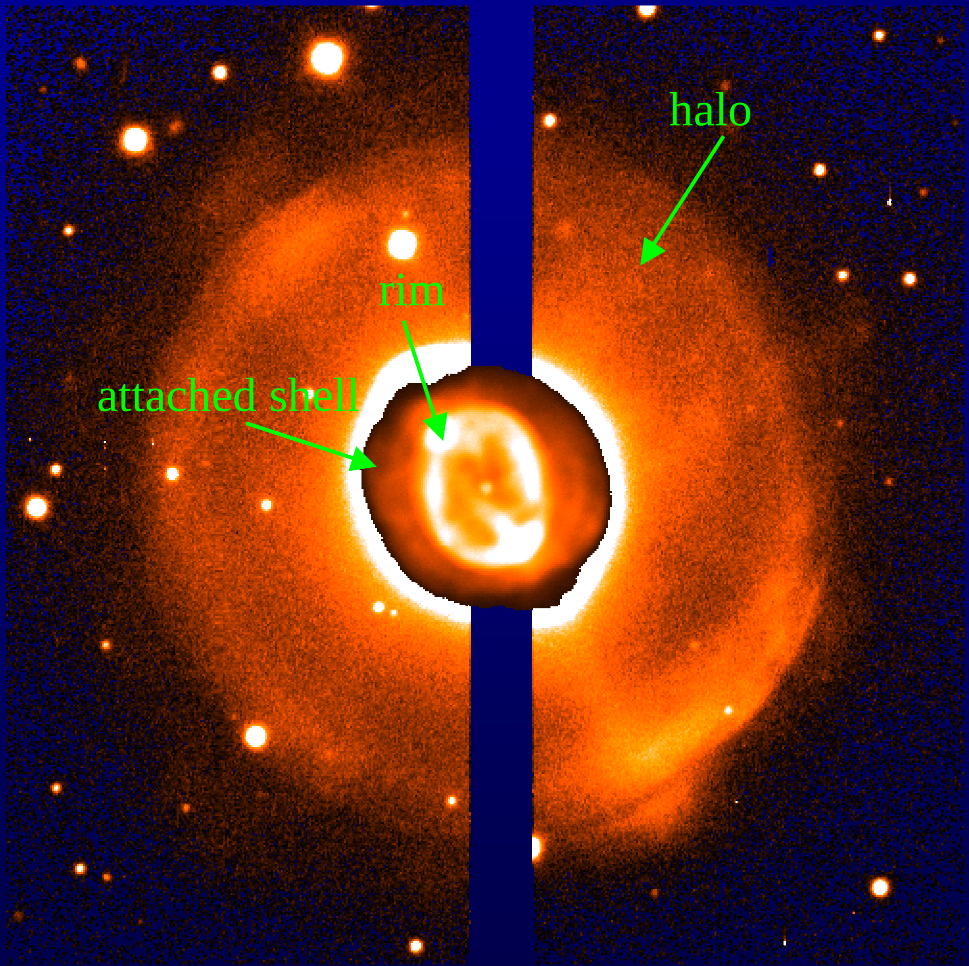


From previous surveys

(Latter et al. 95; Kastner et al. 96; Hora et al. 99; Guerrero et al. 00; Arias et al. 01):

- visible and near-IR morphology are very similar;
- most of the PNe in which H2 was detected are bipolars (waist and/or lobes):
  inside the lobes (young) and
  outside the edge (evolved);
- some non-bipolar PNe also have H2 emission (NGC 6720, J900, NGC 2440);
- H2 is excited by absoption of UV photons in most PNe (NGC 7027). But in others, like NGC 2346 and K 4-47 (Arias et al. 01; Lumsden et al. 01) it is shock-excited;
- the molecular hydrogen distribution "traces" the optical [NII] emission.

Main Components of PNe



NGC 2022

The ***rim*** is the result of the interaction between the fast and slow winds.

The density structure of the ***attached shell*** is determined by the ionization front.

The ***halo*** is ionized AGB matter, and its edge is the signature of the last thermal pulse.

Rims, shells and haloes are better identified in the [OIII] and Hα emission lines.

Microstructures (LIS) of PNe

- very prominent in the low-ionization lines – [OII], [NII] and [SII];
- fainter in Hα;
- almost absent in [OIII].

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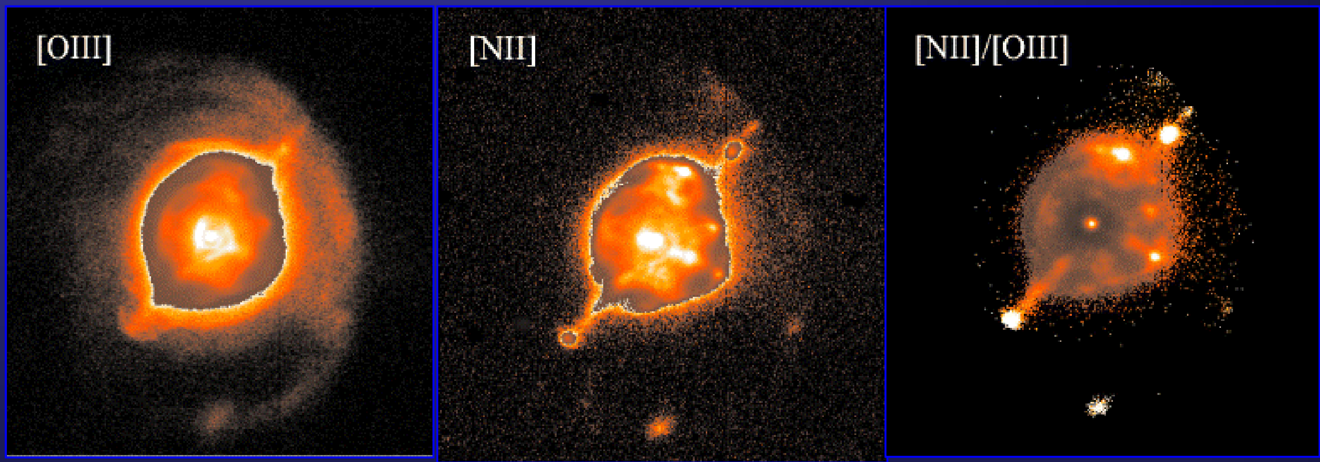
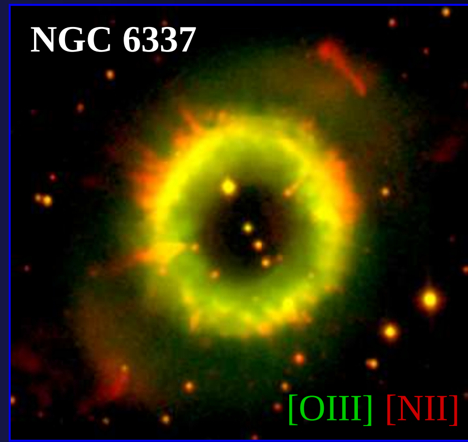
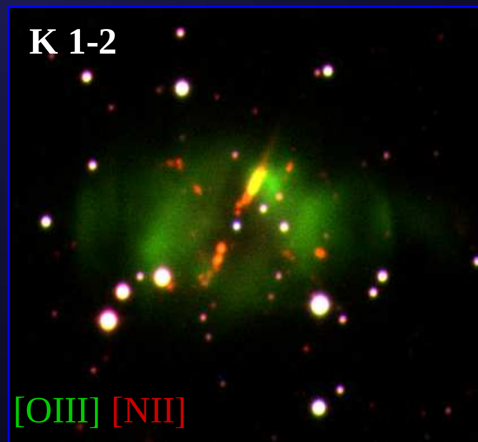
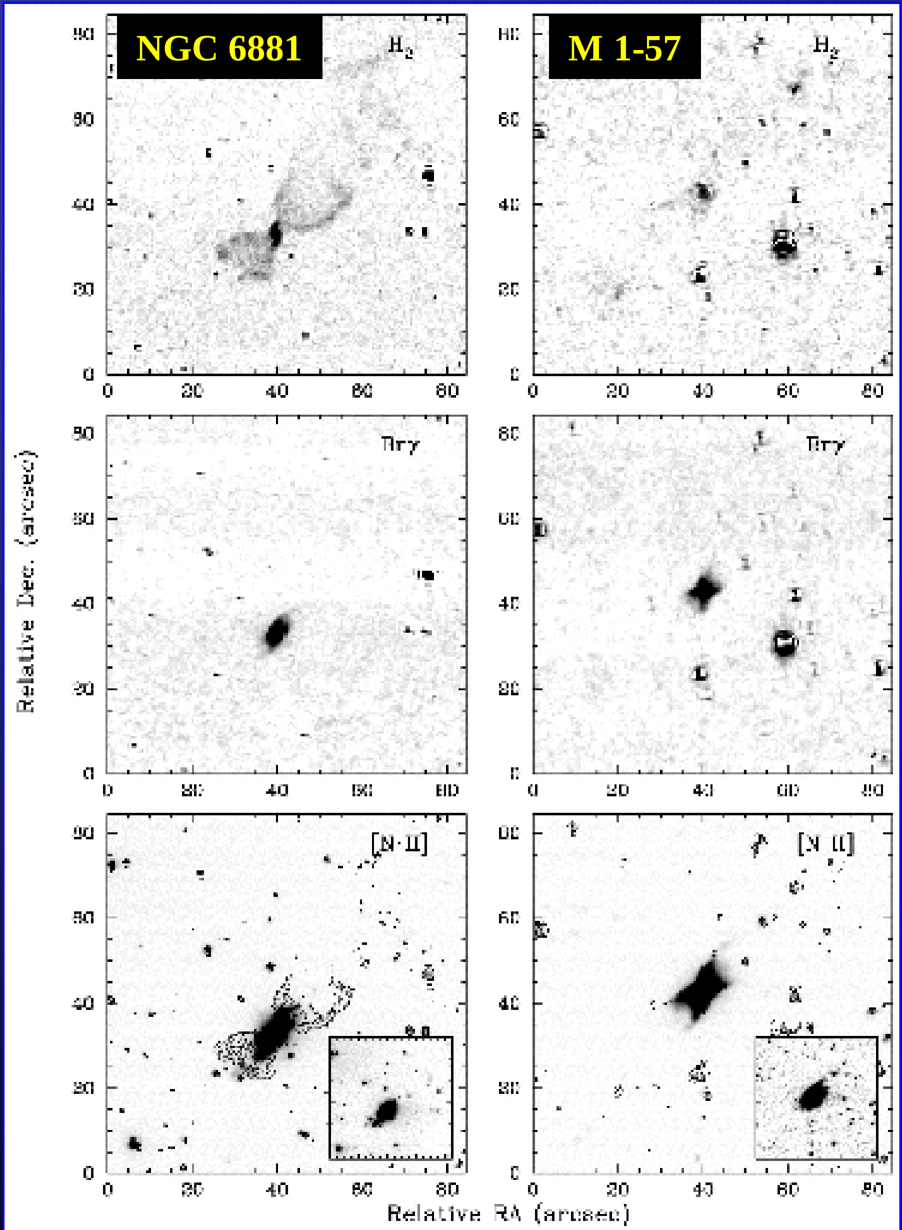




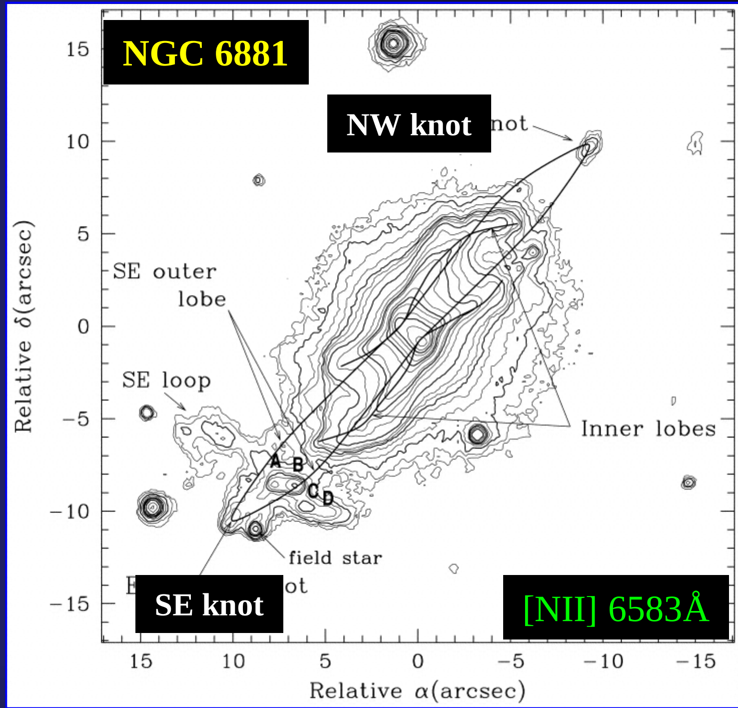
(Balick et al. 98)



What is New in this Proposal?



(Guerrero et al. 00)



(Guerrero & Manchado 98)

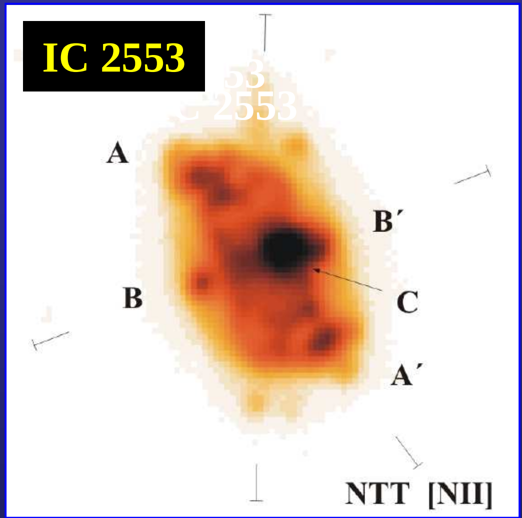
There are no previous observations of H2 associated with LIS!

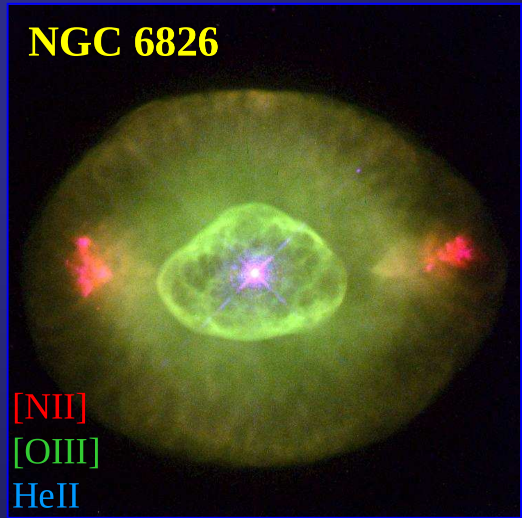
General PNe H2 surveys are not useful for our proposes, because:

- **images are not deep enough**; and
- **lack the high-spatial resolution.**

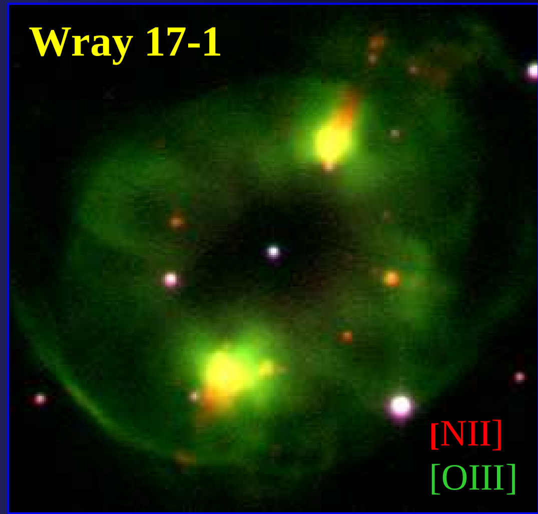
The Implications of Such a Survey...

On Symmetrical Pairs of LIS:





(Balick et al. 98)

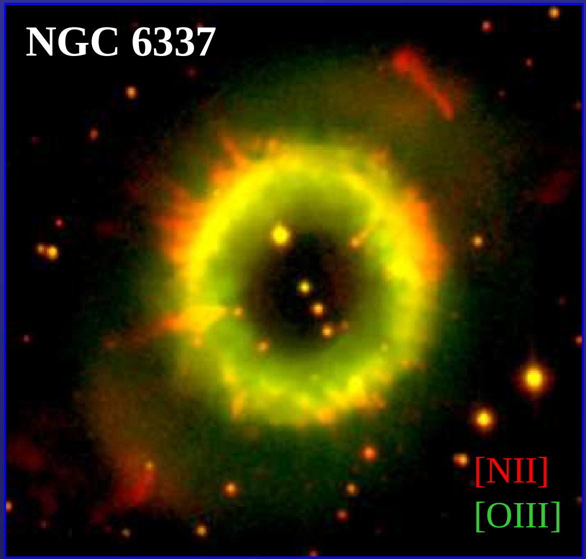


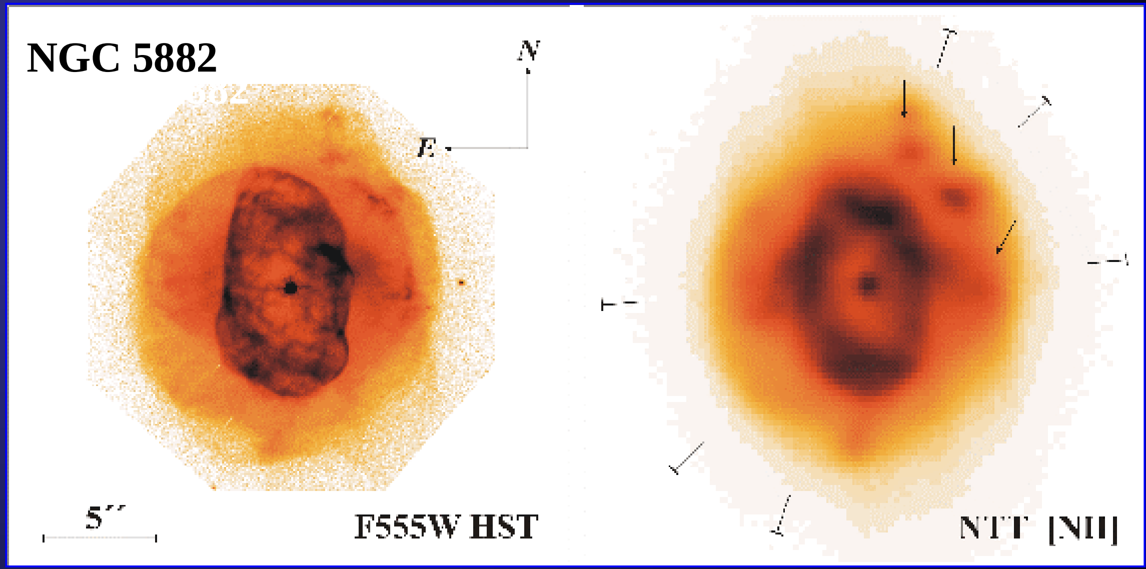
Symmetrical *high-velocity* pairs of knots:
HD or MHD ISW; accretion disk systems; stagnation zones
(García-Segura et al. 01; Steffen et al. 01).

Pairs of *low-velocity knots* are less studied theoretically.
We suggest => they are fossil ejections of the AGB wind
=> implying a very peculiar AGB mass-loss geometry
(Corradi et al. 00; Gonçalves et al. 01).

The Implications of Such a Survey...

On Isolated LIS:





May be formed by in situ instabilities or
fossil AGB mass-loss inhomogeneities.

From their positions, they are not related to dynamical instabilities due to the action of the fast post-AGB wind.

The Rocket Effect (Mellema et al. 98) can, in some cases, explain the peculiar velocities.

The Implications of Such a Survey...

First: the detection of H2 associated with LIS will prove their origin as remnants of the AGB wind, because most of the material of this wind remains neutral in form of dust grains, molecules and atoms.

Second: can “solve” the problem of very collimated low-velocity features.

Third: can give us important constraints on the behavior of the winds in (post-)AGB stars.

Comparison with theoretical model predictions: H2 can survive in mild ionization regions inside PNe, so that it affects the physical/chemical condition of the gas (Aleman & Gruenwald 04).

➡ We will be able to compare the predictions of this model with the spatially resolved H2 distribution for a sample of PNe.

Other Relevant Relations…

H2 is detected mainly in bipolars. So…

it comes from higher mass progenitors;
with stronger winds;
from Galactic disk PNe.

But LIS appear indistinctly in all morphological classes...

One key question on PNe formation is the onset of their asymmetry

- the change from something approx. spherical to something elliptical, bipolar, quadrupolar or even point-symmetric occurs very rapidly at the end of the AGB phase.
- but the mechanisms that drive the asymmetry is still unknown.
- if we prove that LIS are fossil AGB features => so, we will prove that discrete (not spherical) mass loss occurs even early in the central star evolution.
- proto-PN and PNe, which still have signatures of the molecular envelopes are ideal to address these relevant issues.