A first look at Galactic PNe

A PLANCK Intermediate paper by PLANCK Collaboration

presented by G. Umana INAF-OACt, Italy

WG 7.5 Late stages of stellar evolution



Setting the scene...

Evolutionary phase undergone by star with MS 0.8 -8 Mo

$10^4 L_{\odot}$...and the actors





Spectral evolution AGB=> PNe

Model of spectral evolution in the AGB-> PNs phase (Volk 1992)



PLANCK will provide spectral information in a *scarcely explored* observational band: -to complete the radio and I R data

-Use spectral information provided by PLANCK to build the spectral energy distribution (SED) of a sample of PNe.

-Morphological study of extended emission (Helix)

-To derive physical properties of CSE Mass (gas, dust), T, multi components -how they change with evolution

Very important in the framework of Galaxy chemical evolution as PNe, and their progenitors, among major sources of recycled I SM.

We want to quantify and qualify the material returned to ISM

Sample of radio bright Galactic PNe

A total of 119 sources with both 30 and/or 43 GHz data (single dish)

- Noto (32m) 43 GHz
- beam=52 " (Umana et al., 2008)
- Torun (32m) 30 GHz beam=1.2 ' (Pazderska et al., 2009)

Expected contribution to both LFI (free-free) and HFI (free-free + dust)



11 PNe of the sample reported in the ERCSC (detected at least in 3 chs)

Non-blind source extraction at each PLANCK channel

- at positions of our Galactic Planetary Nebulae Catalog
 - LFI Mexican-Hat algorithm (Lopez-Caniego t al., 2007;

Gonzales-Nuevo et al., 2006)

HFI aperture photometry

Robustness:

-Non-blind source extraction
-detection in a minimum of 3 channels (S/N ≥ 3)
-knowledge of the field (high resolution maps available)

Final sample of 11 PNe

Planck Data



Characterization of CSE:

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-ionized gas (free-free)
-dust (thermal I R)
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Output: M_{ion}, M_{dust}, T_{dust}, R_S, R_{CSE}

A quest for the best model

Ferland et al., 1998

CLOUDY: Good for modeling the dust component, fails in the optically thick part of the radio spectrum

I vezic et al., 1999

Best solution: a combination of DUSTY and a free-free code written for such purpose

SED modeling



Open squares: ancillary measurements (several, including IRAS, AKARI) Filled squares: PLANCK data (30, 44, 70, 143, 217, 353 GHz)

SED modeling



Open squares: ancillary measurements (several, including IRAS, AKARI) Filled squares: PLANCK data (30, 44, 70, 100, 143, 217, 353, 545, 857 GHz)

SED modeling



FOV 1.5'x1.5'

Open squares: ancillary measurements (several, including IRAS, AKARI) Filled squares: PLANCK data (30, 44, 70, 217, 353, 545, 857 GHz)

A study case: CRL 618 a PN in the making



CRL 618 is rapidly evolving to a PN

radio emission varies on a 20yrs consistent with an expanding HII (Umana et al., 2012)



Strong variability in mm range has been also reported

(Sanchez-Contreras and Sahai, 2004)

CRL 618: a PN in the making

Data collected by different instruments spanning more than 10 years... SED modeling..nonsense!

PLANCK offers the <u>unique</u> possibility to build the SED with almost simultaneous measurements: no effects due to variability.



Speck et al., 2002

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One of the closest (213pc) and more evolved (extended) PNe. Studied in different spectral ranges and at different spatial scales (Speck et al., 2002; O'Dell et al., 2004; Hora et al., 2006)



20

dust

30



-30 -20

20

10

30

-10

0

△ Ra (arcmin)

10

-30

20

-30

-20

-10 0

△ Ra (arcmin)

10

20

-30 -20 -10 0 GV. △ Ra (arcmin)

-30 -20 -10

0

△ Ra (aremin)



Planck maps – High frequencies maps quite similar tracing the same dusty structure

First morphological study of the cold dust in the Helix



An inner hole consequence of central UV???

A main ring of emission (≈300")









The north-east component indicates a region where interaction with ISM takes place.



H₂ image provided by J. Hora

Dust and H2 distribution quite similar: Observational evidence for H2 formation on dust grains?

Dust versus molecular and ionized gas

Molecular component (elongated) well inside dust I onized gas (roundish), well inside dust and H_2



Dust versus molecular and ionized gas



The unique frequency coverage of **PLANCK** has allowed:

1) a comprehensive picture of CSE of Galactic PNe $M_{ion} \approx 10^{-2} M_{sun} M_{dust} \approx 10^{-2} M_{ion}$ usually cospatial (shielding mechanism)

- CRL 618 -very YPNe

2) Morphological study of dust in the Helix comparison with the molecular and ionized gas component

More results foreseen with future PLANCK releases -Halos around PNe? Big grains in PPNe?

Strong synergy with **ALMA** (higher resolution studies)

The scientific results that we present today are the product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada-

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA) and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.



Extra-slide- HERSCHEL



