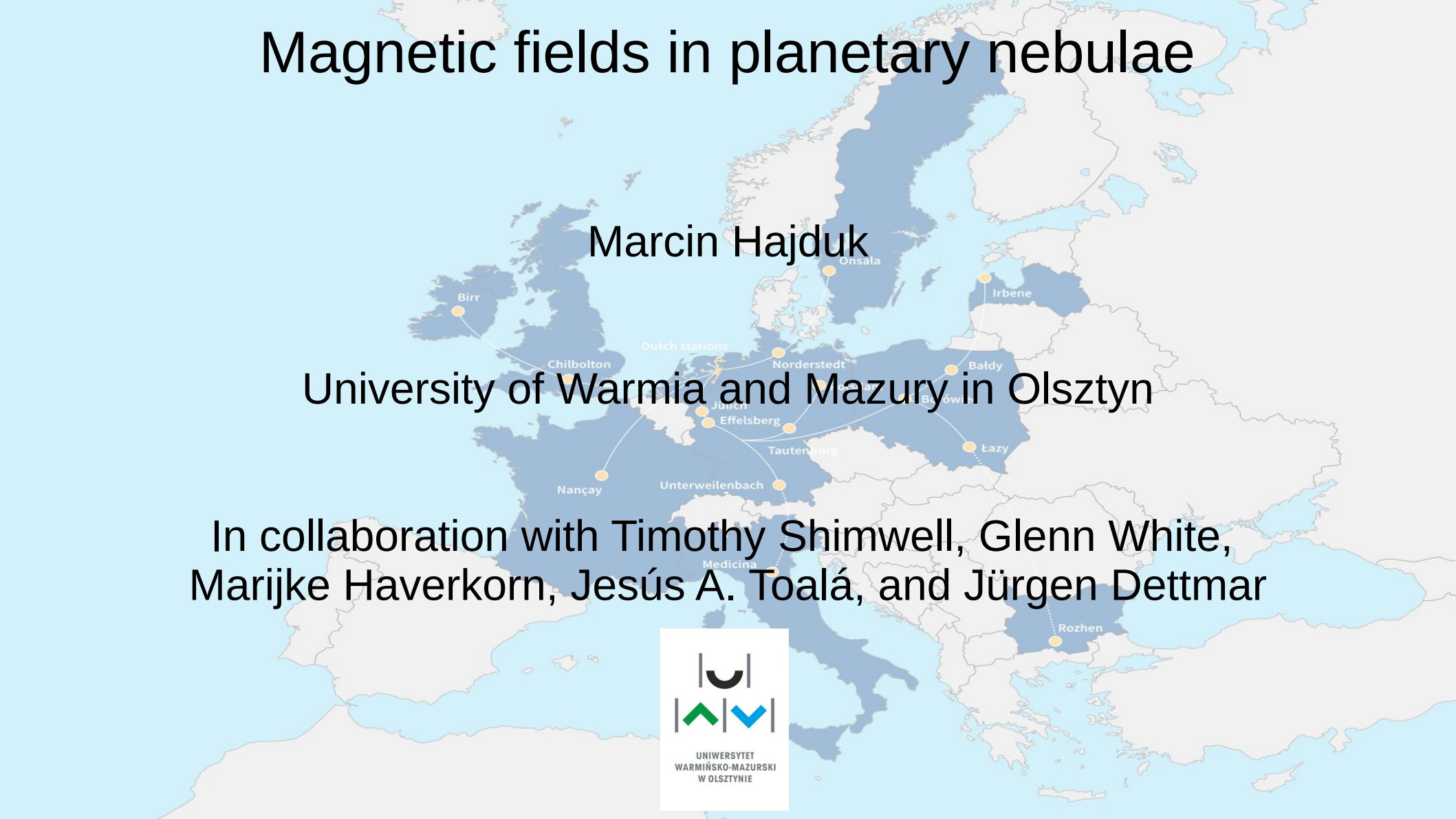
Magnetic fields in planetary nebulae

Marcin Hajduk

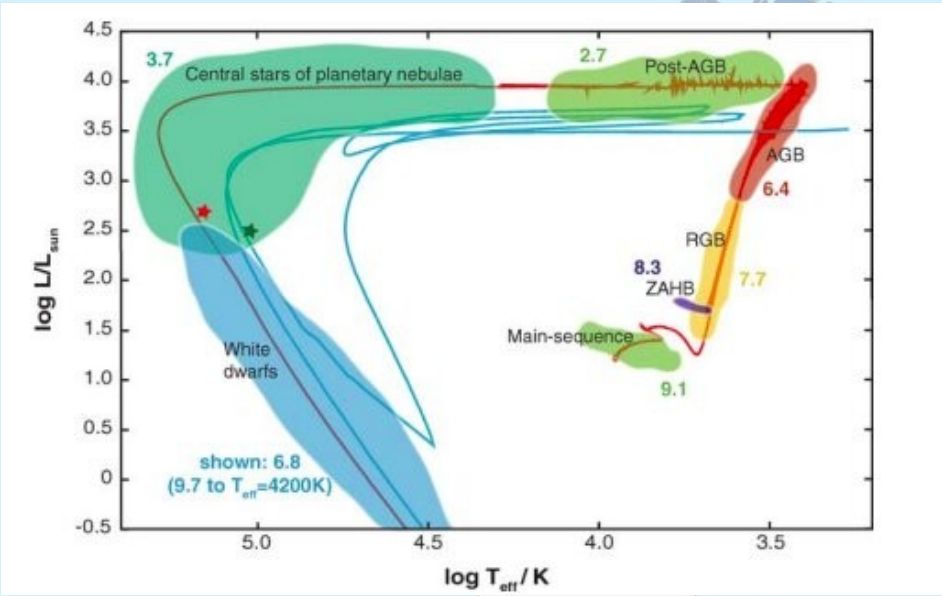
University of Warmia and Mazury in Olsztyn

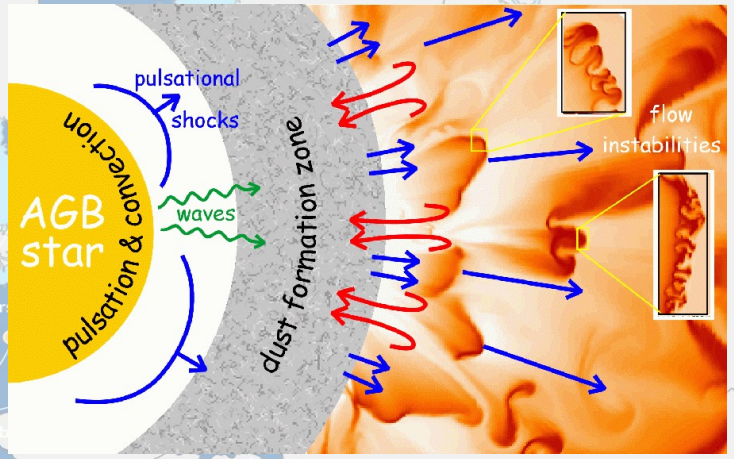
In collaboration with Timothy Shimwell, Glenn White, Marijke Haverkorn, Jesús A. Toalá, and Jürgen Dettmar

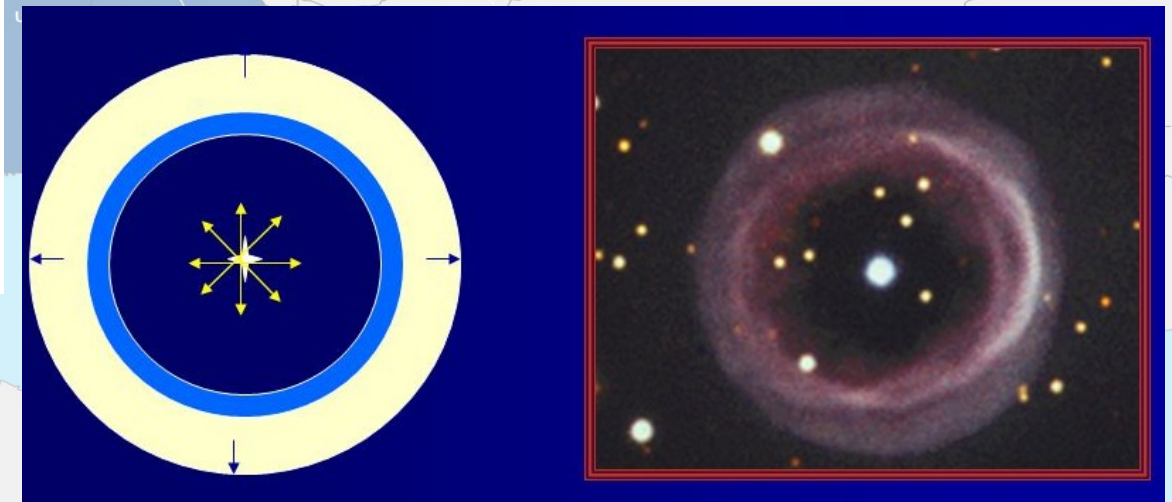


UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE

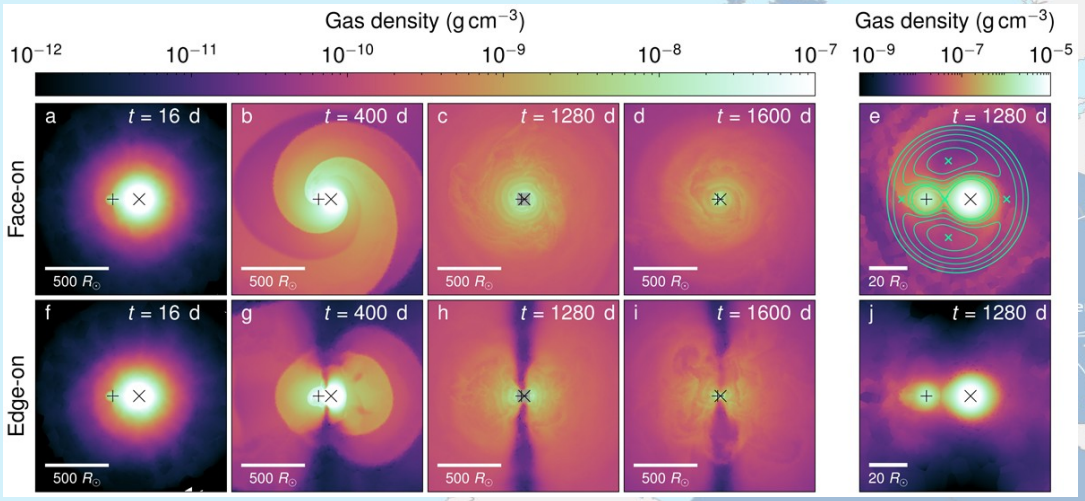
Formation of a PN



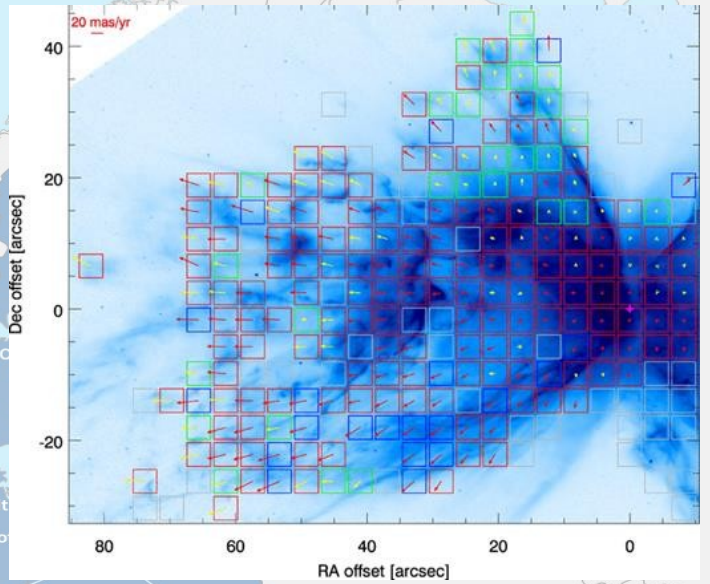


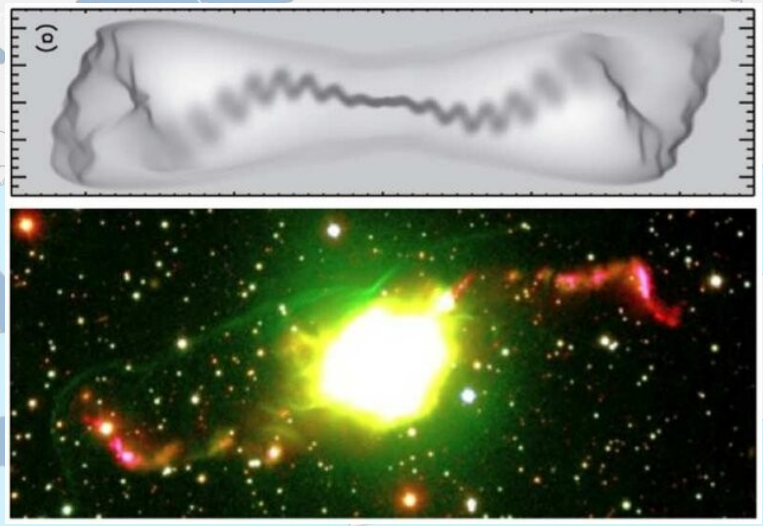


Szyszka, C., et al., 2011, MNRAS, 416, 715



Ondratschek, P., et al., 2022, A&A, 660L, 8





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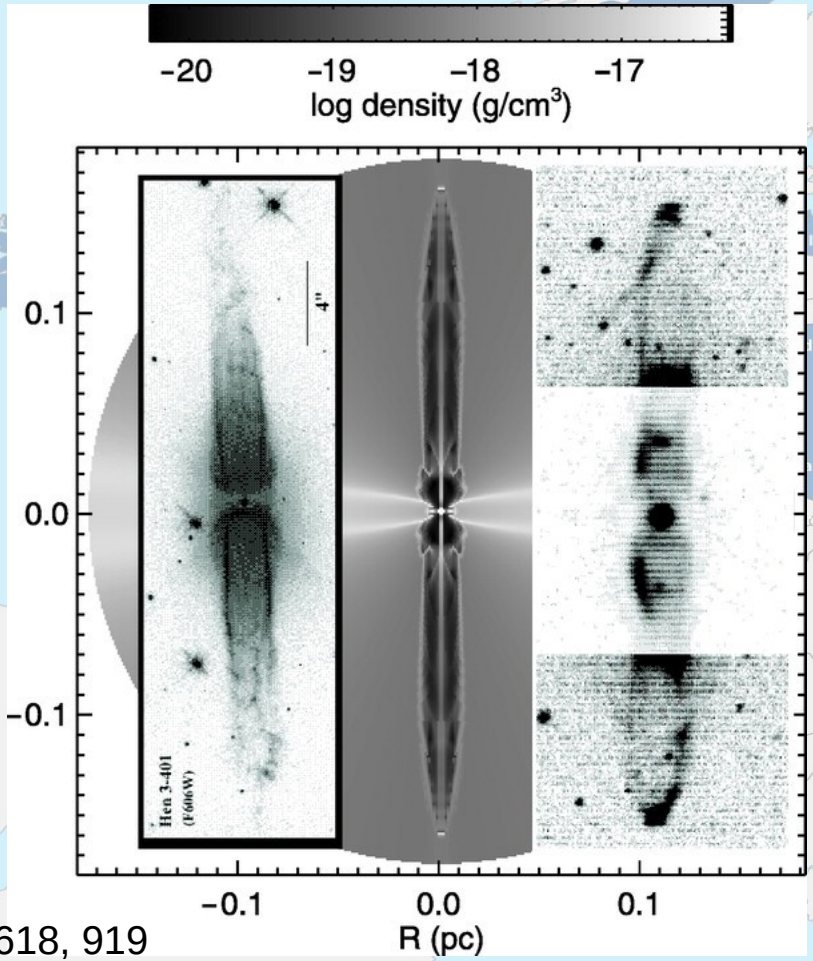
Magnetic fields in PNe: collimated wind from the star



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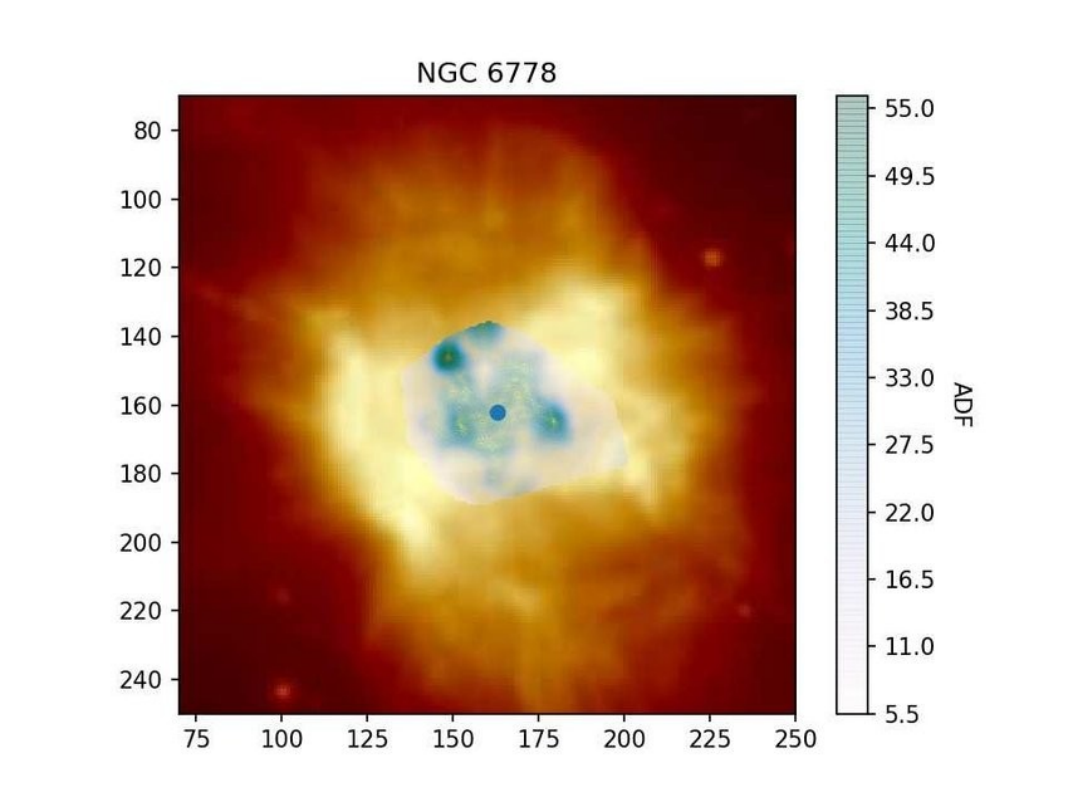
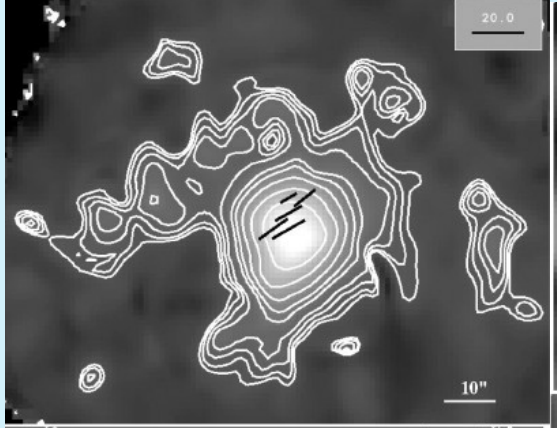
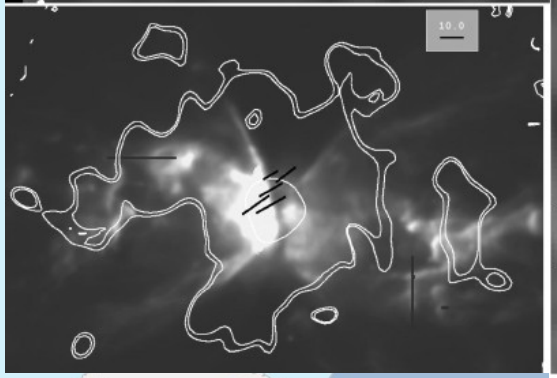
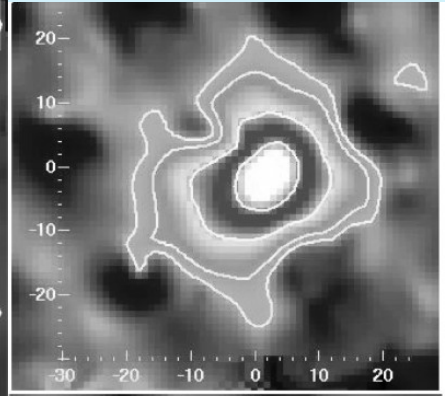
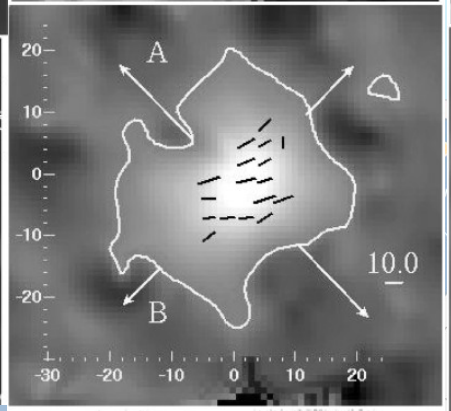
Hot bubbles, cold blobs

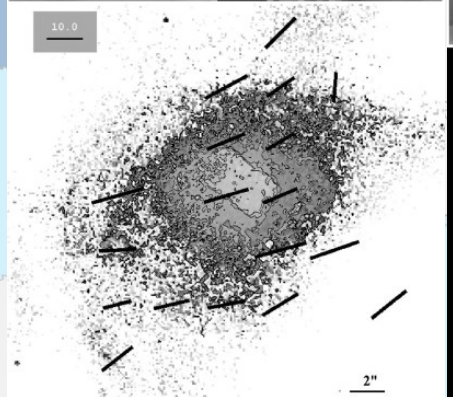


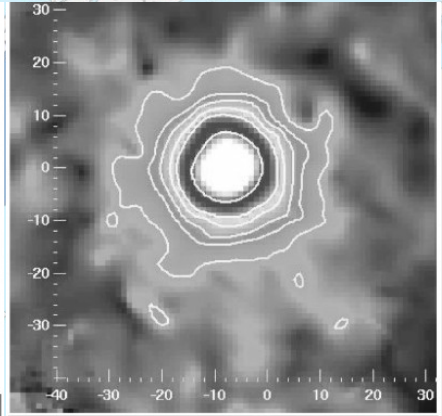


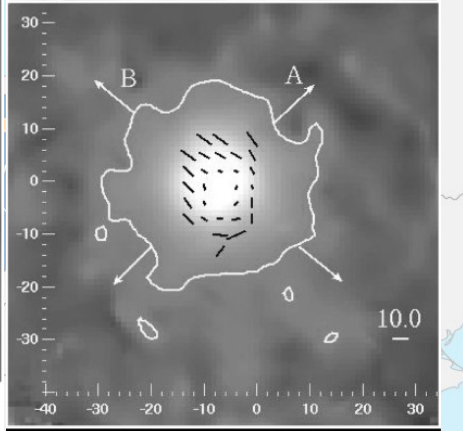


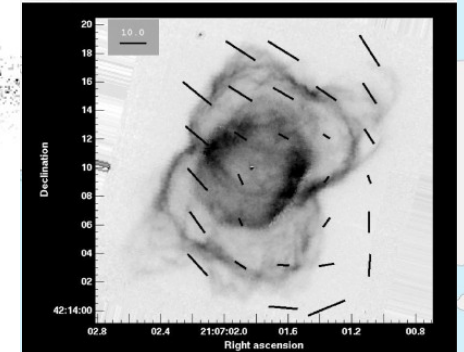






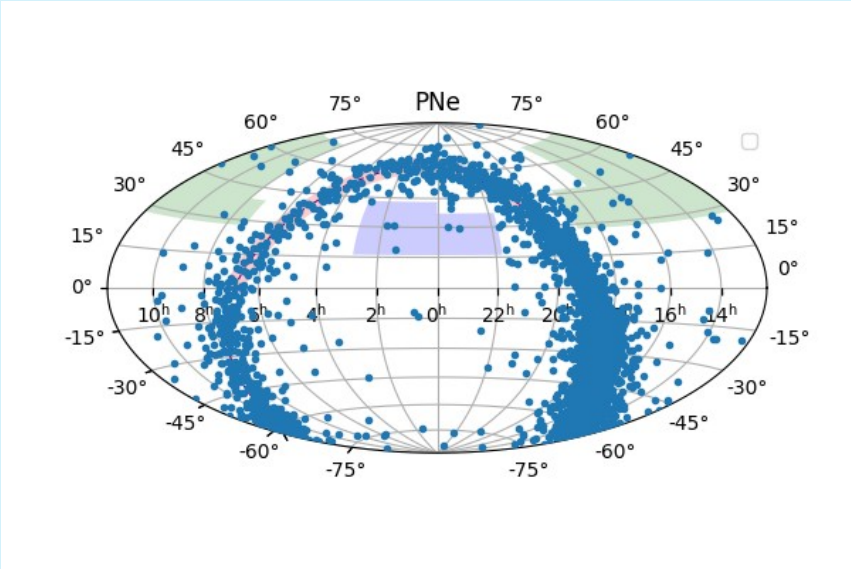


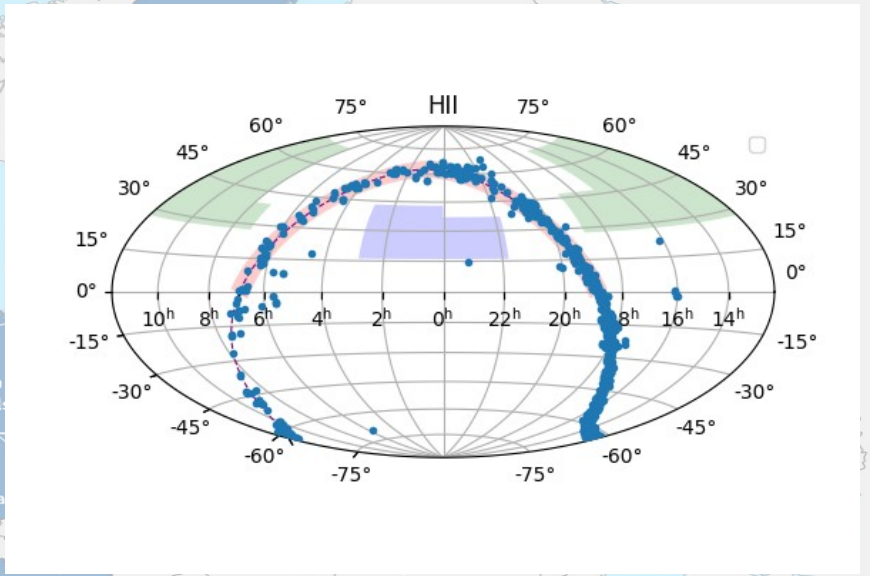


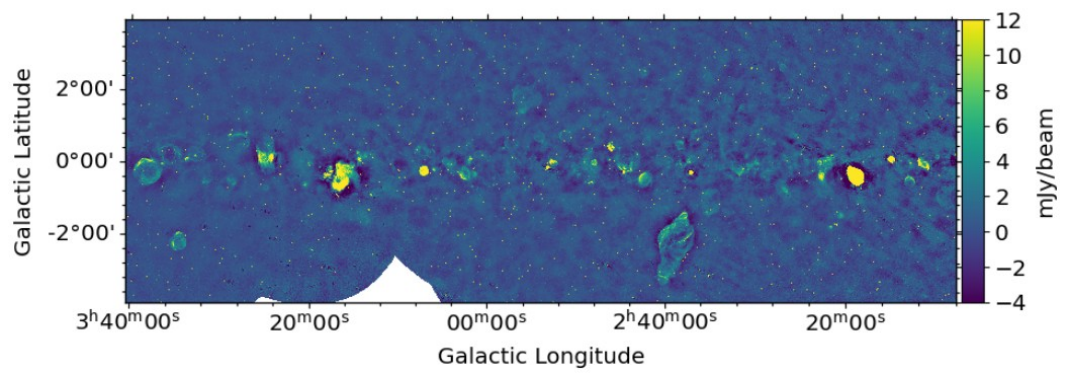


Sabin L., et al., 2015, MNRAS, 376, 378

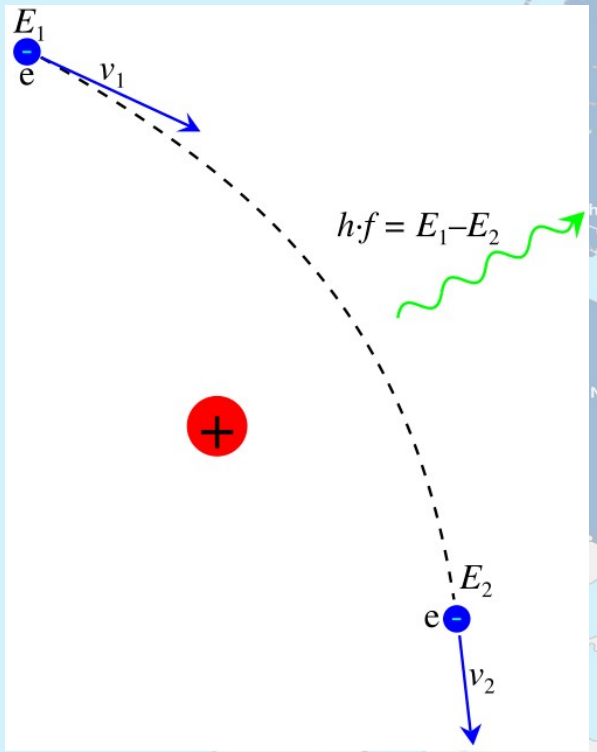
Distribution of planetary nebulae and HII regions

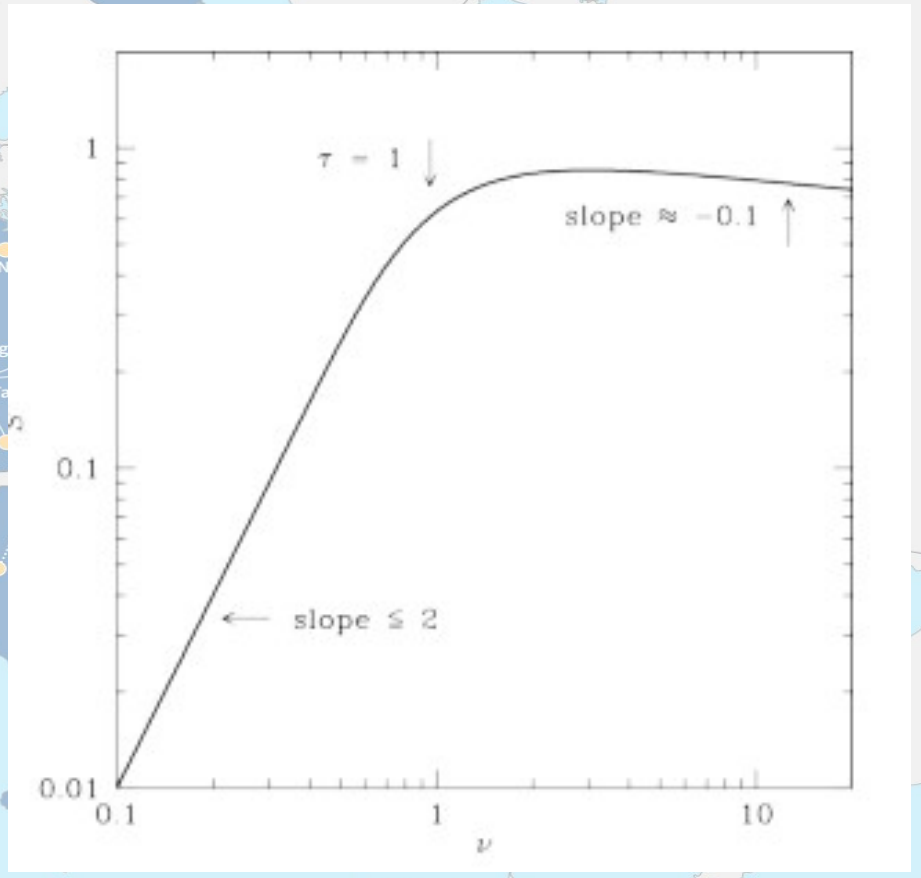




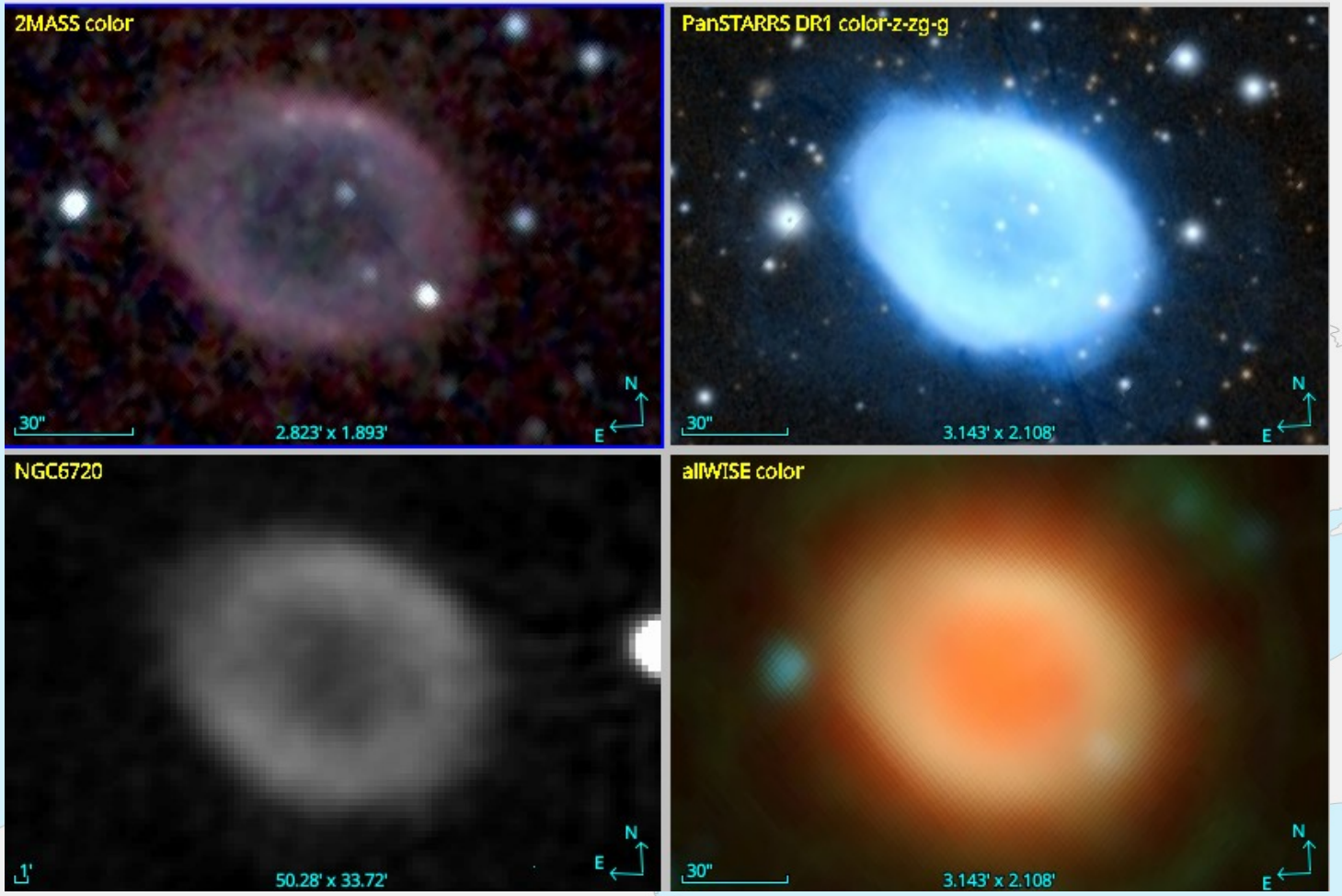


Thermal radio emission

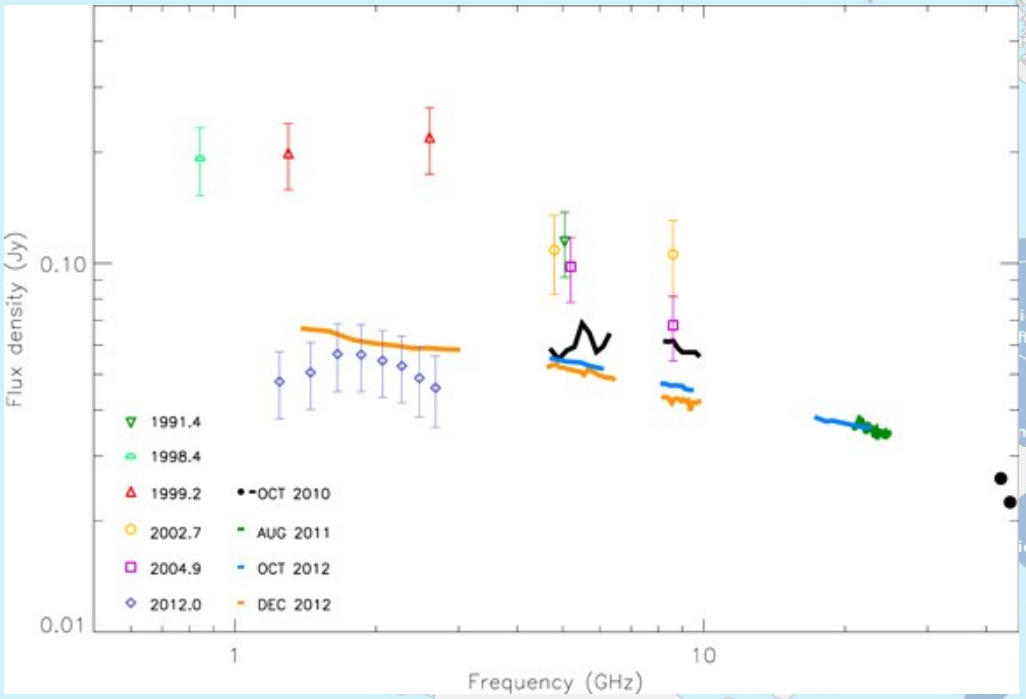




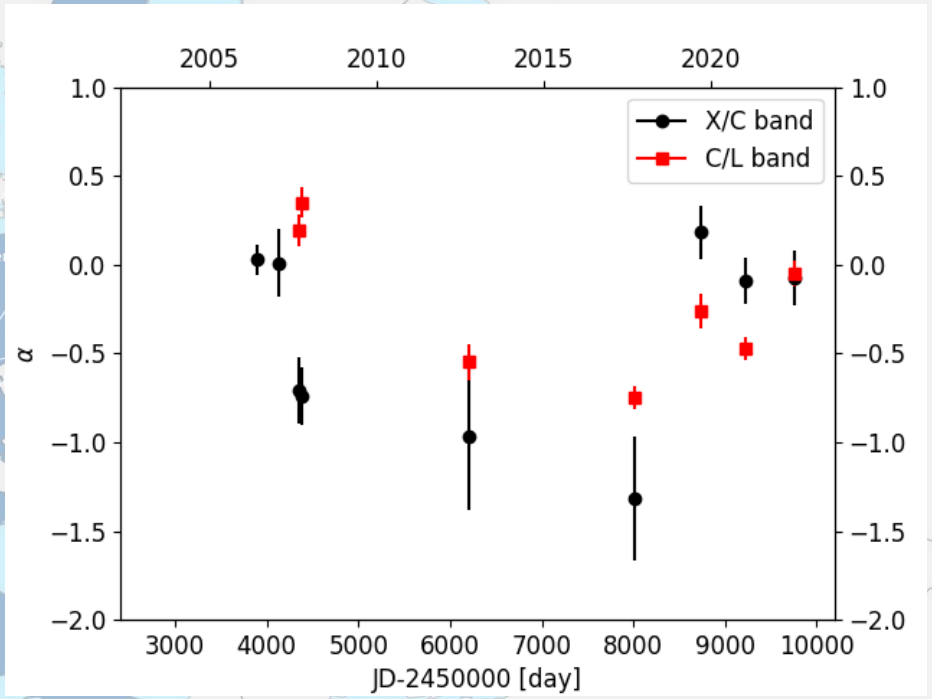
Ring nebula at different wavelengths



Non-thermal radio emission

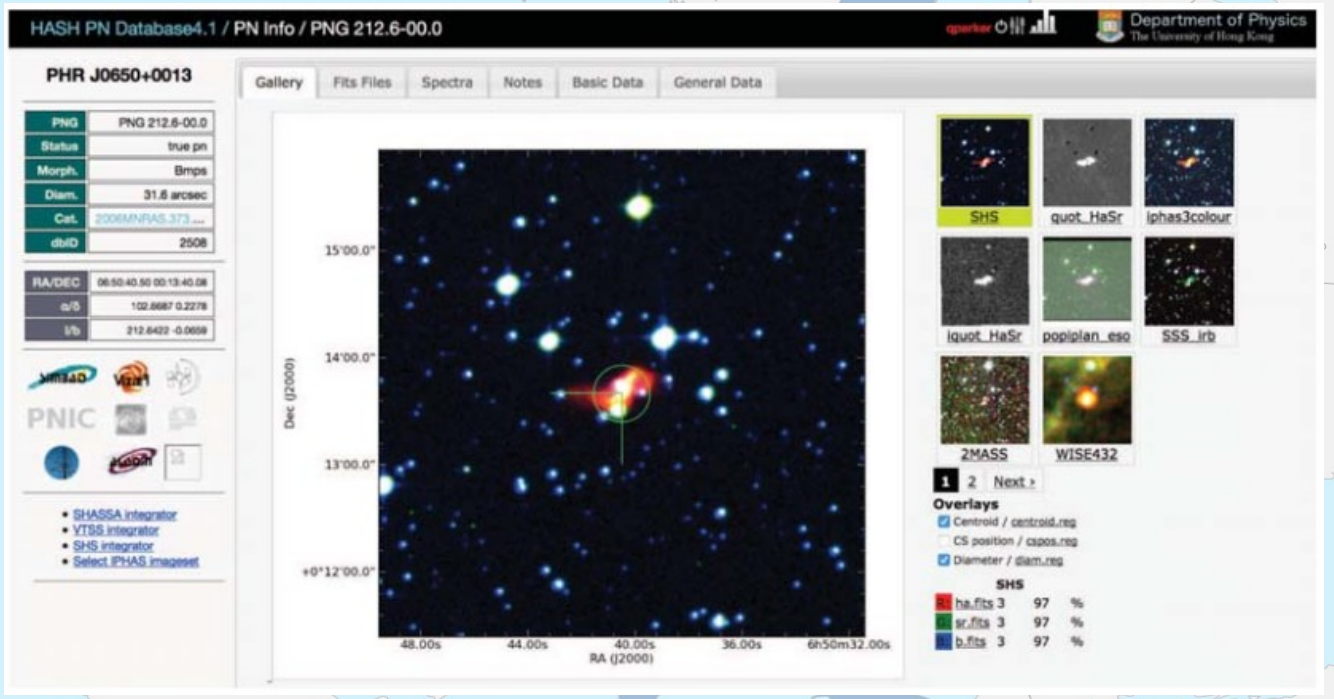


Suarez O., et al., 2015, ApJ, 806, 105



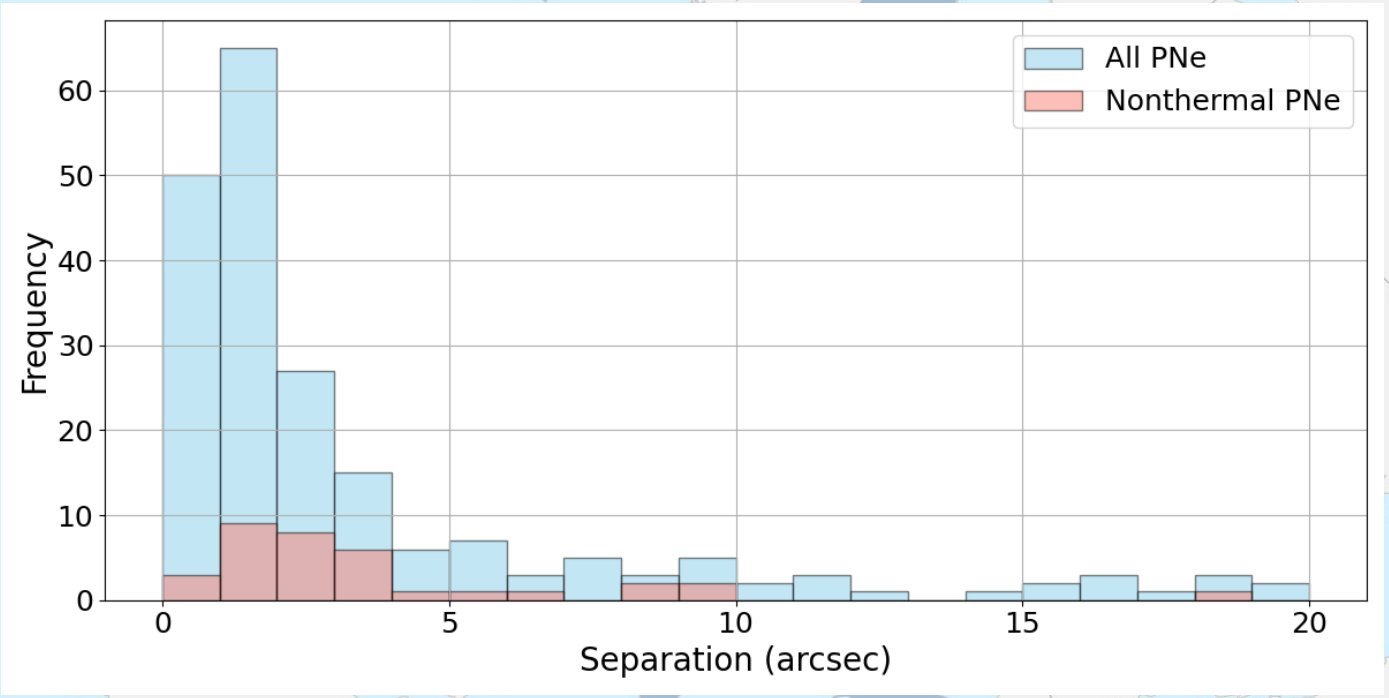
Hajduk, M., et al., 2024, A&A, 688L, 27

H-alpha Planetary Nebula (HASH PN) database, existing radio surveys

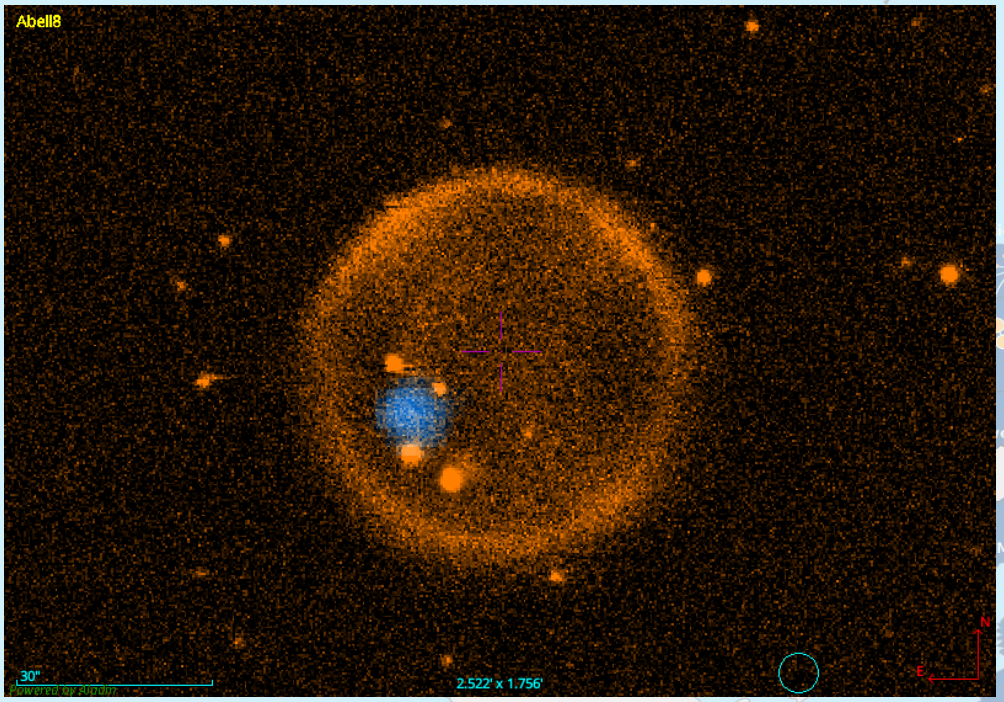


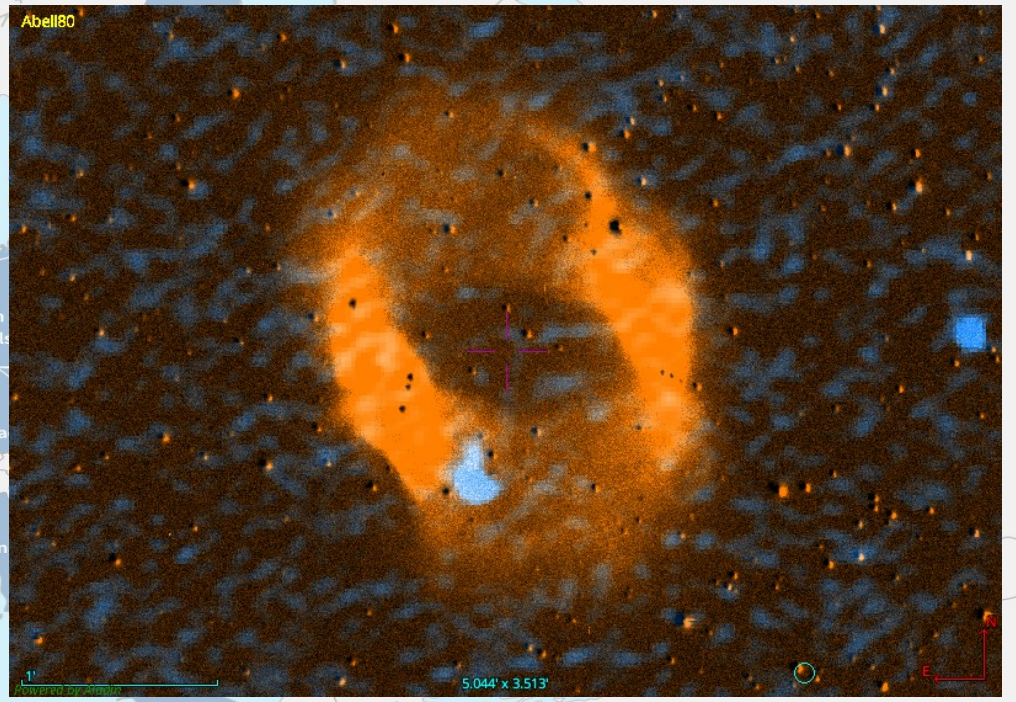
Parker Q., et al., 2016, JPhCS, 728, 2008

Identification of PNe in LoTSS

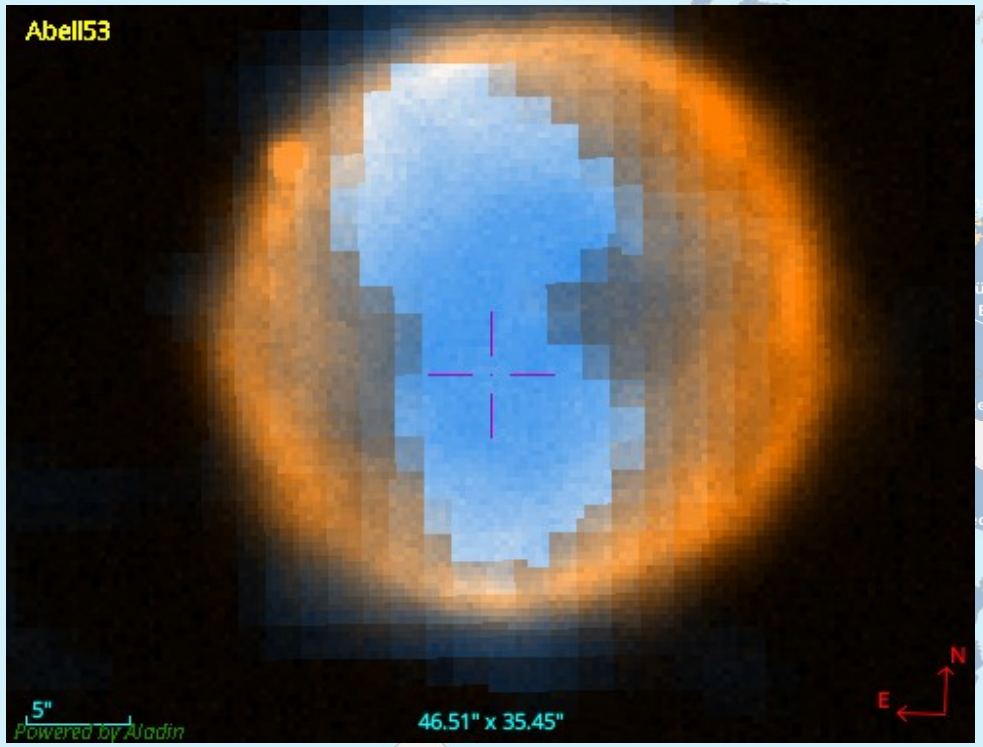


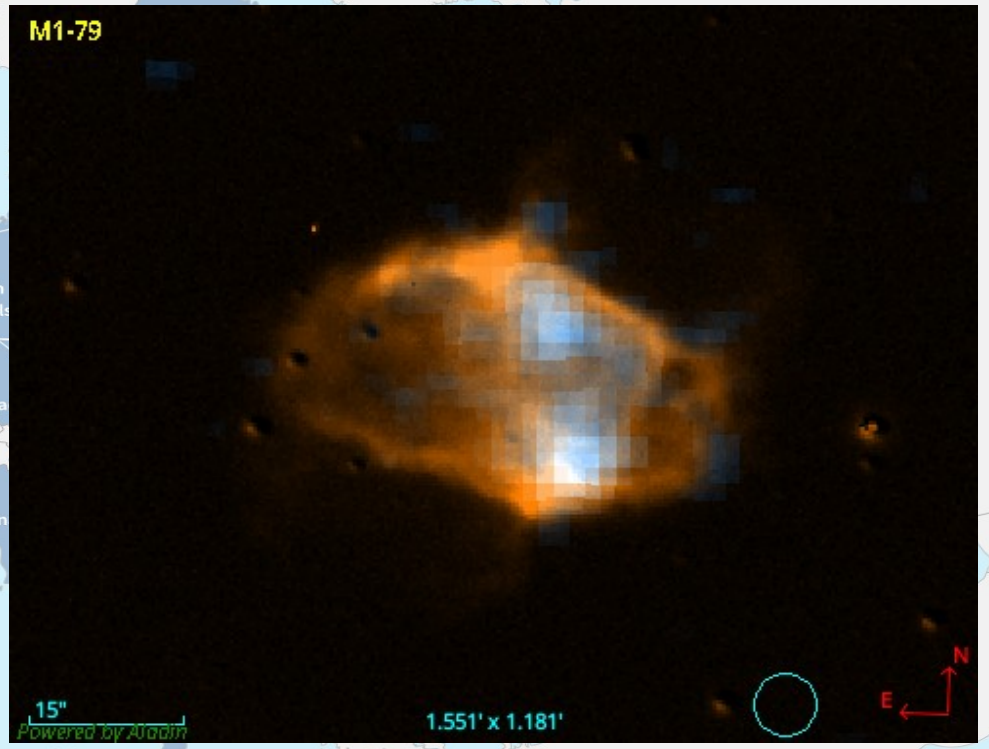
Additional verification



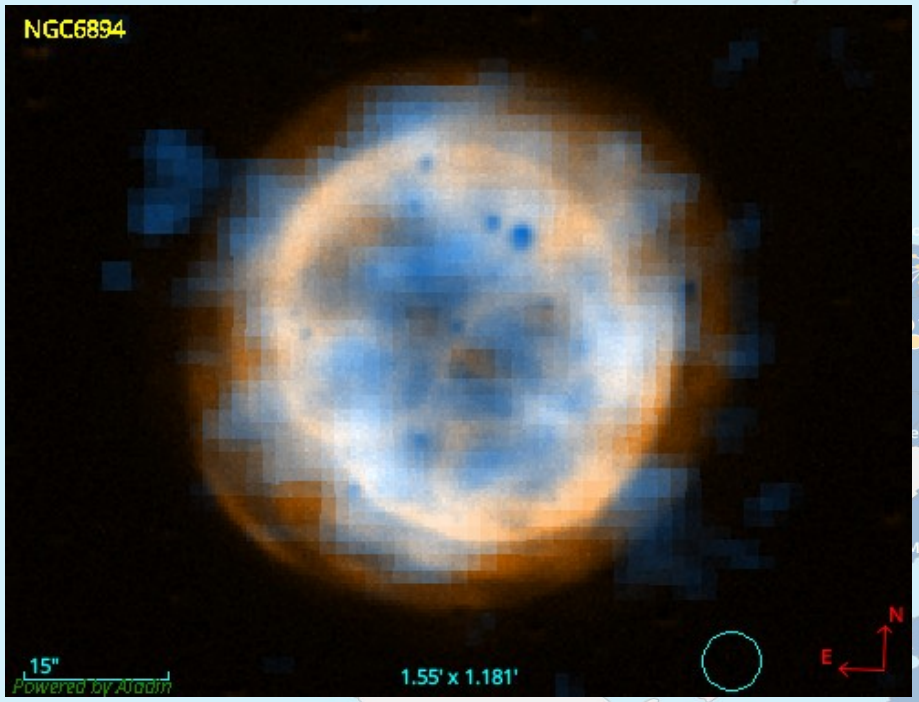


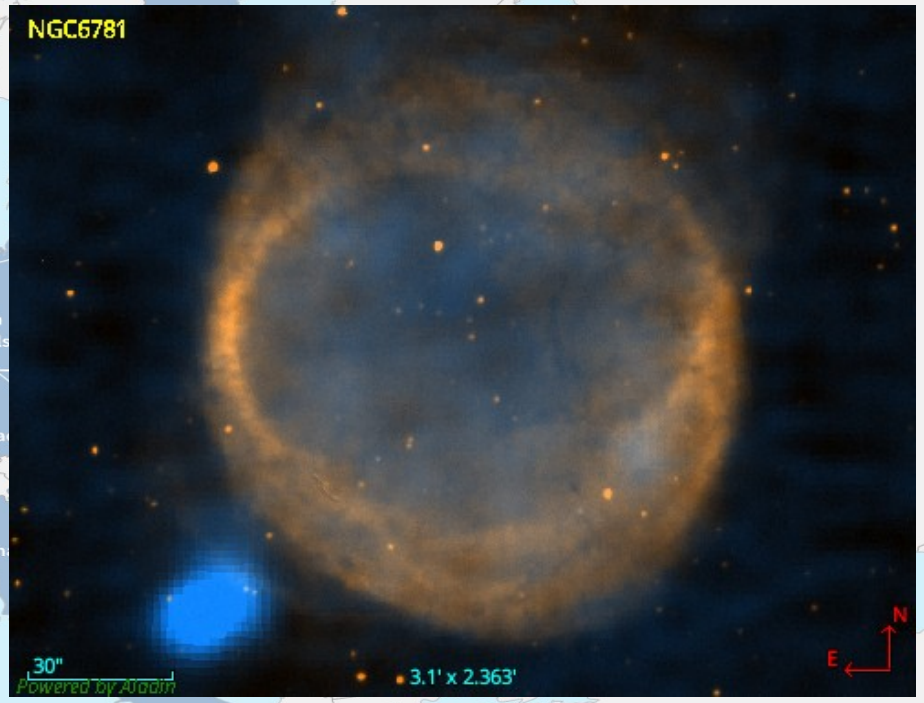
Bipolar radio emission



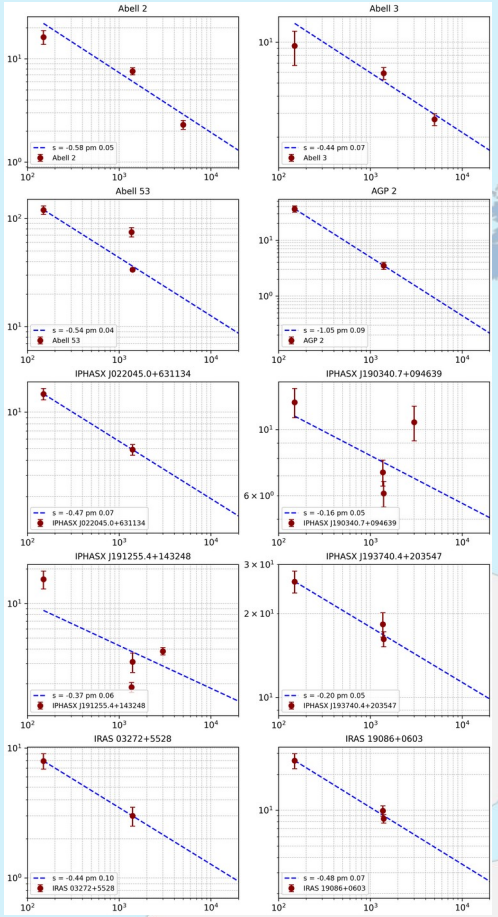


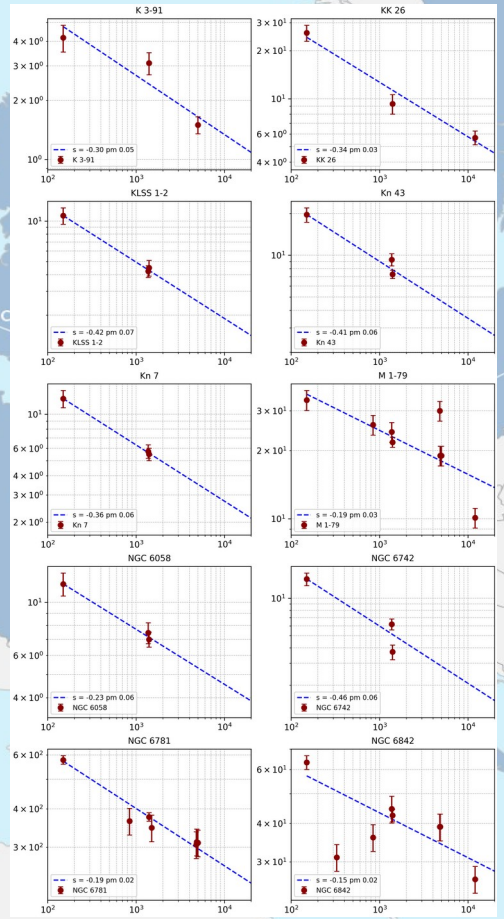
Radio emission filling nebula

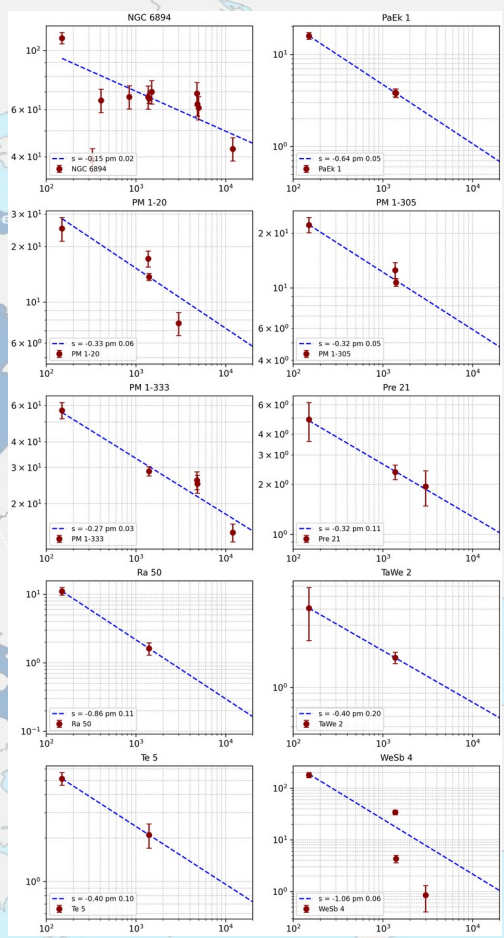




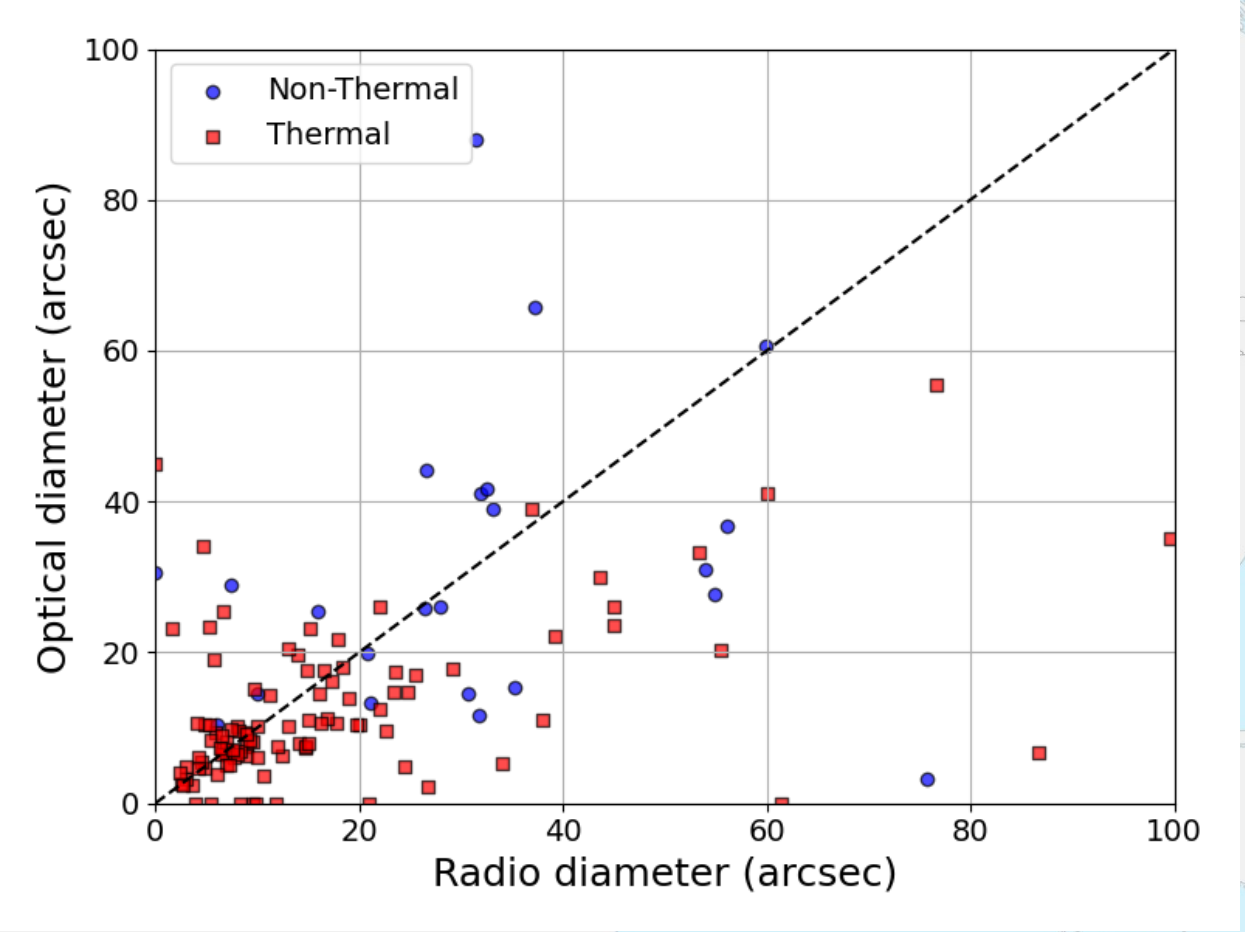
Radio spectra of non-thermal PNe



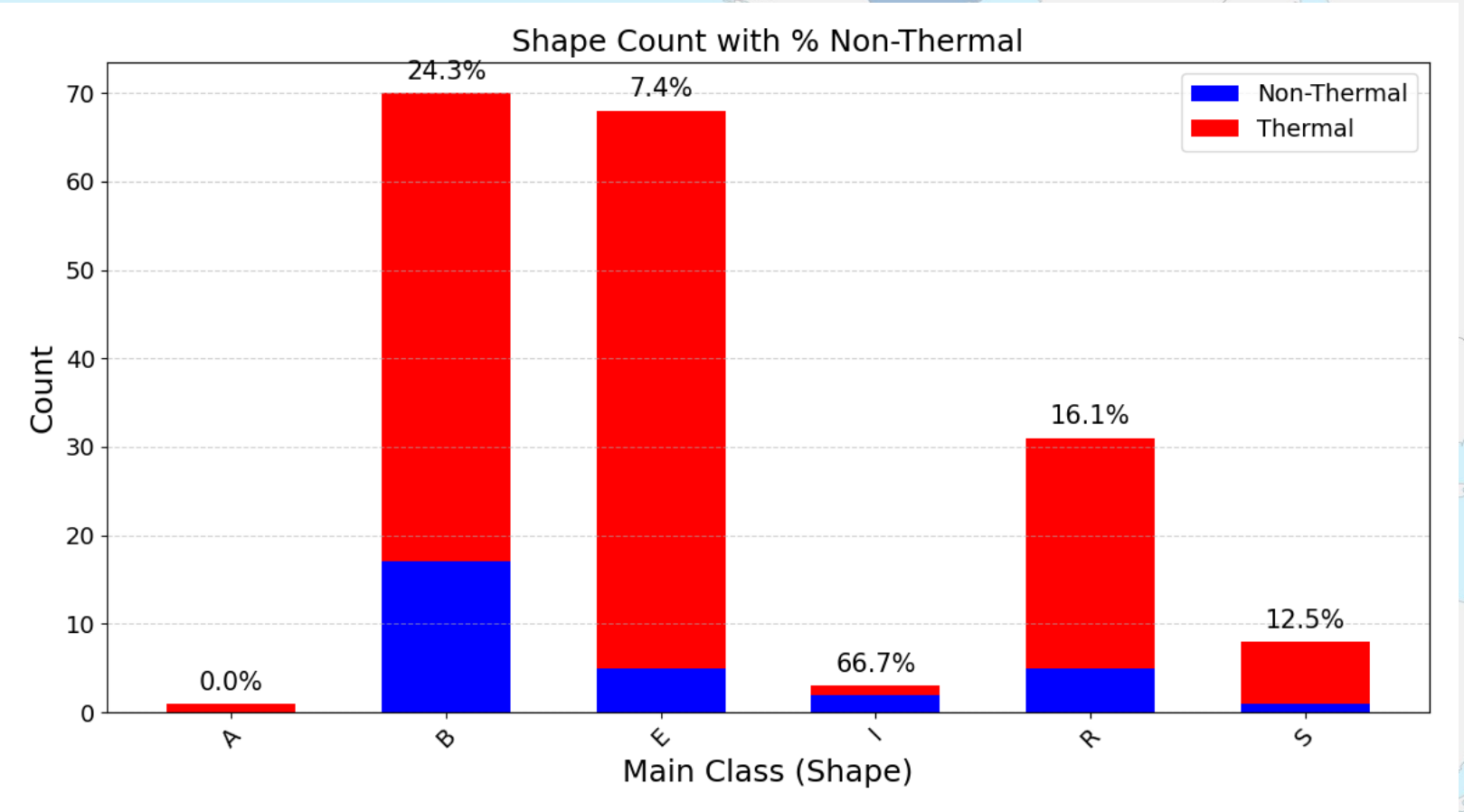




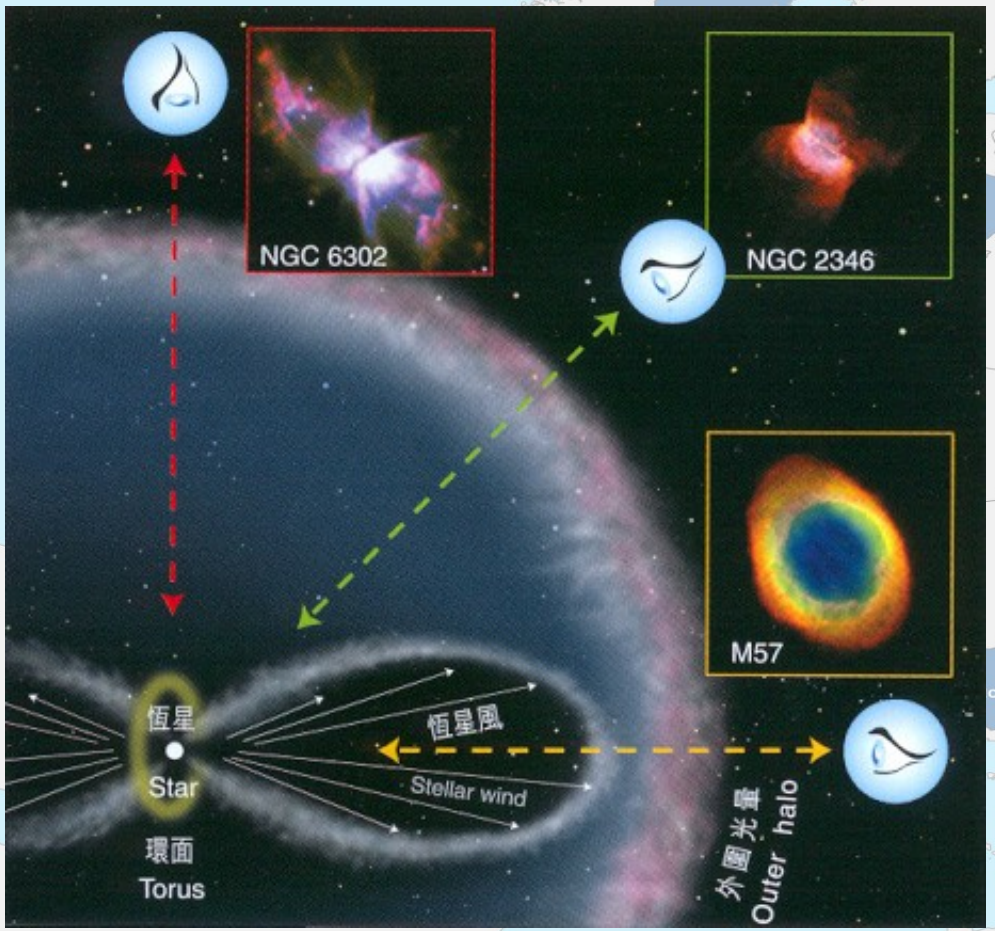
Type of emission vs size



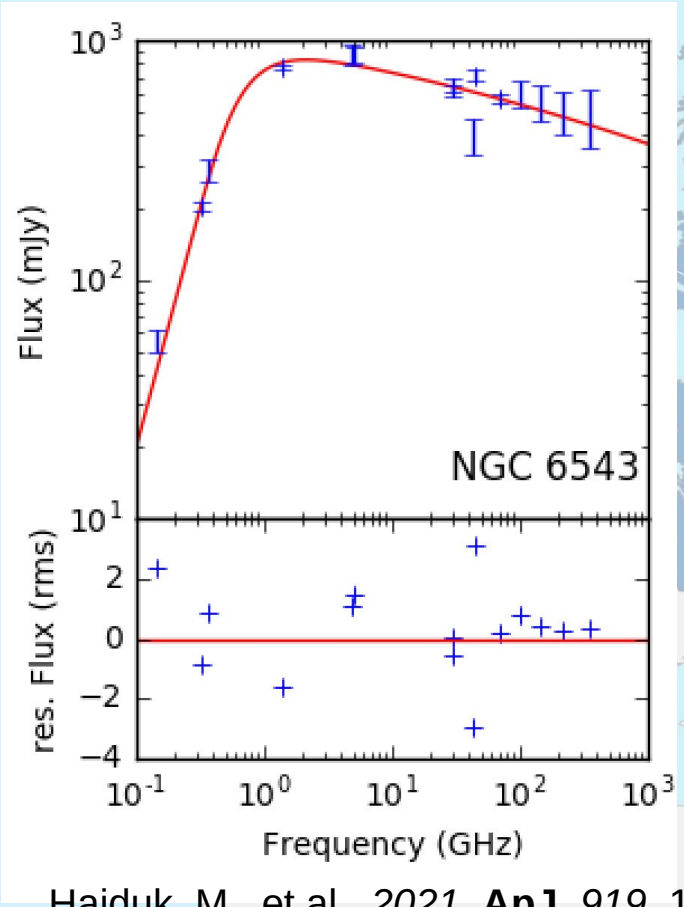
Occurence of non thermal emission vs morphology

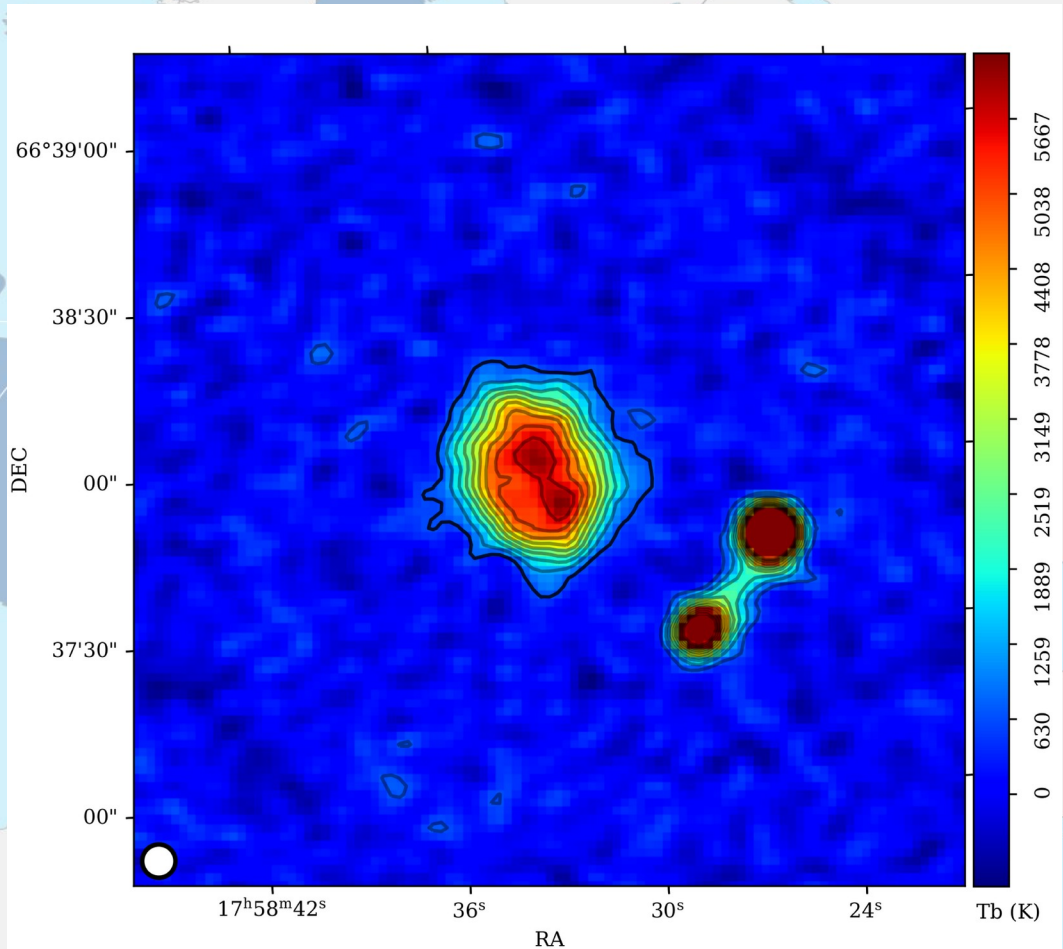


Projection effects



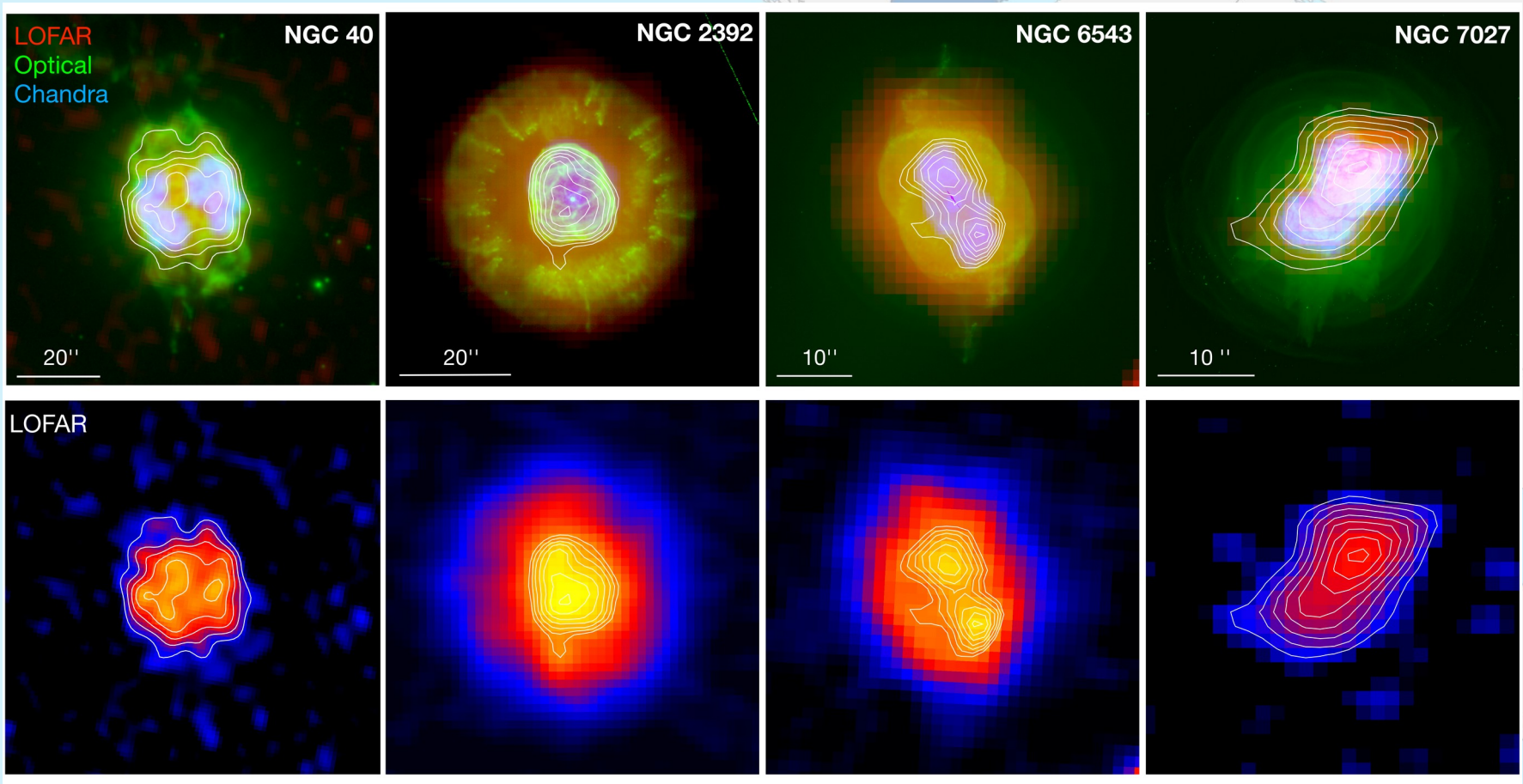
Mixed thermal and non thermal emission?



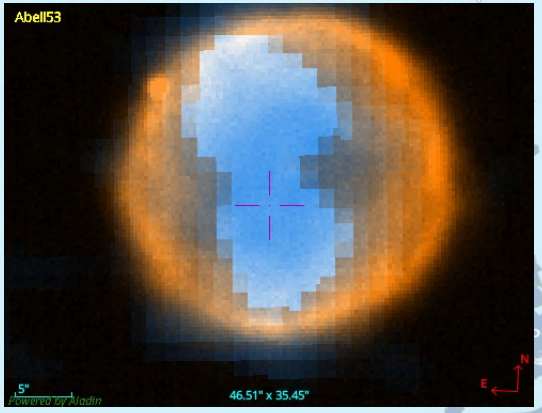


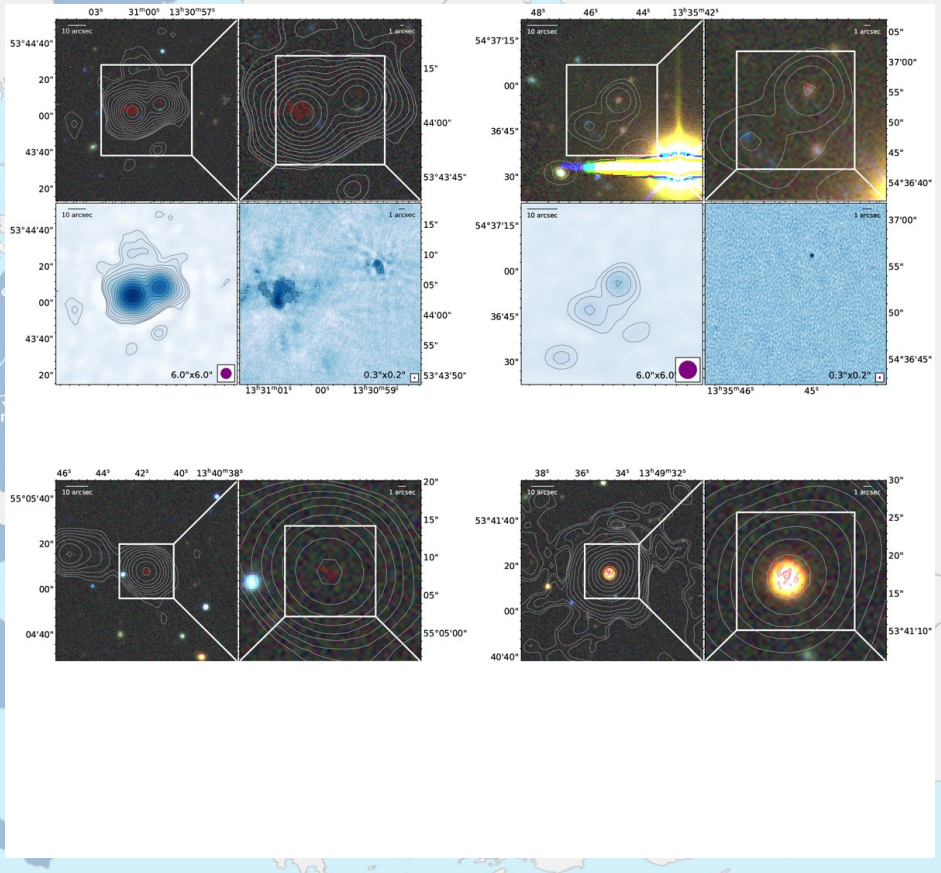
Hajduk, M., et al., *2021*, **ApJ**, *919*, 121

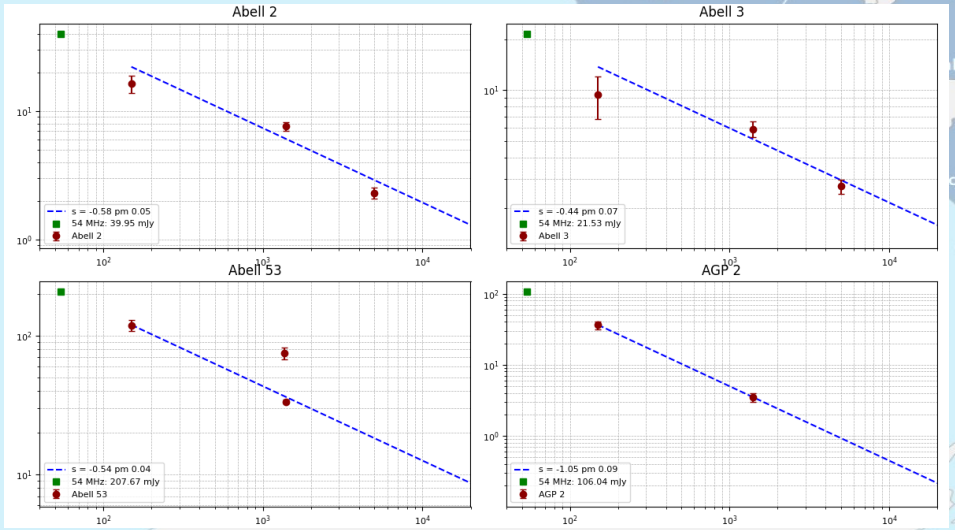
144 MHz excess correlated with X-ray emission



VLA P-band @350MHz or/and LOFAR VLBI or/and LBA







Morabito, L., et al., 2022, 658, 1

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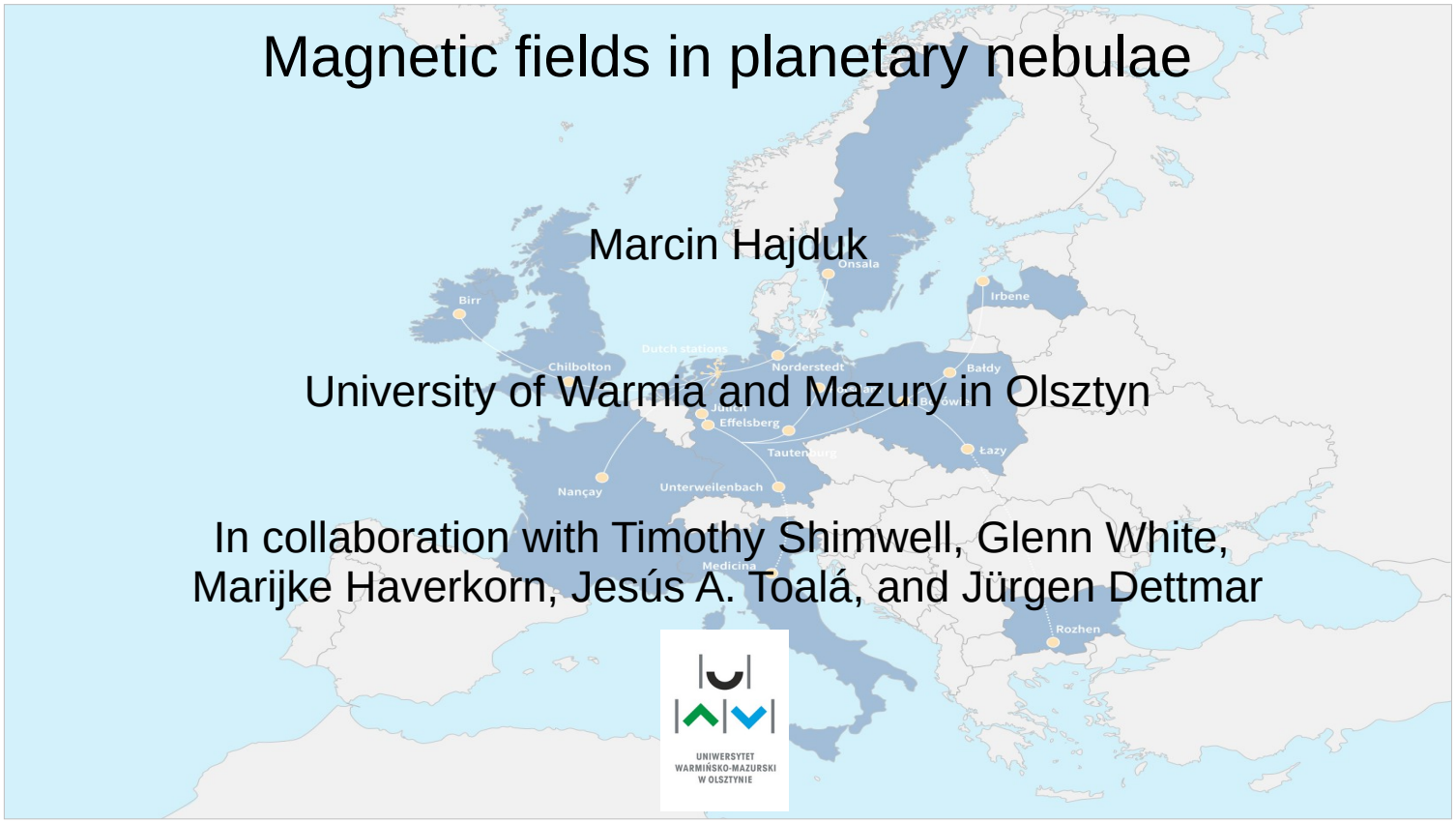
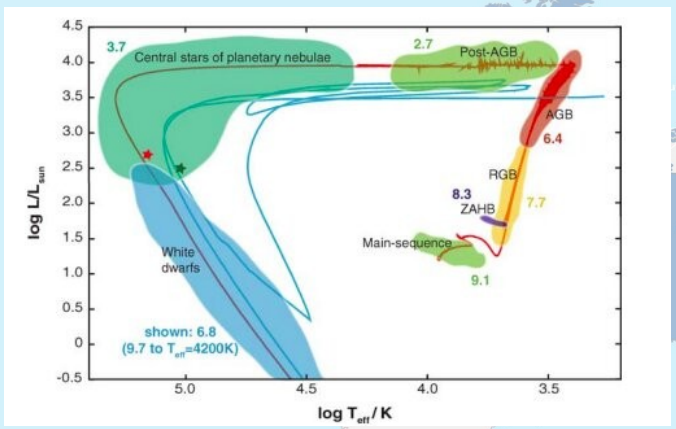
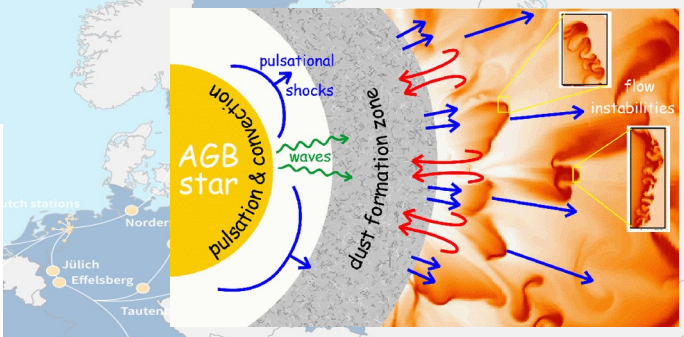
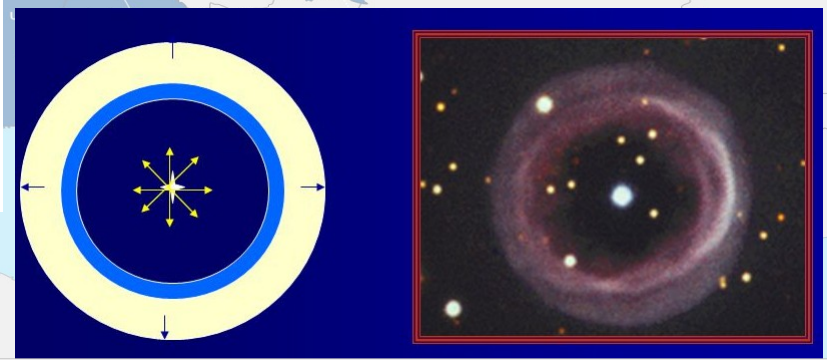
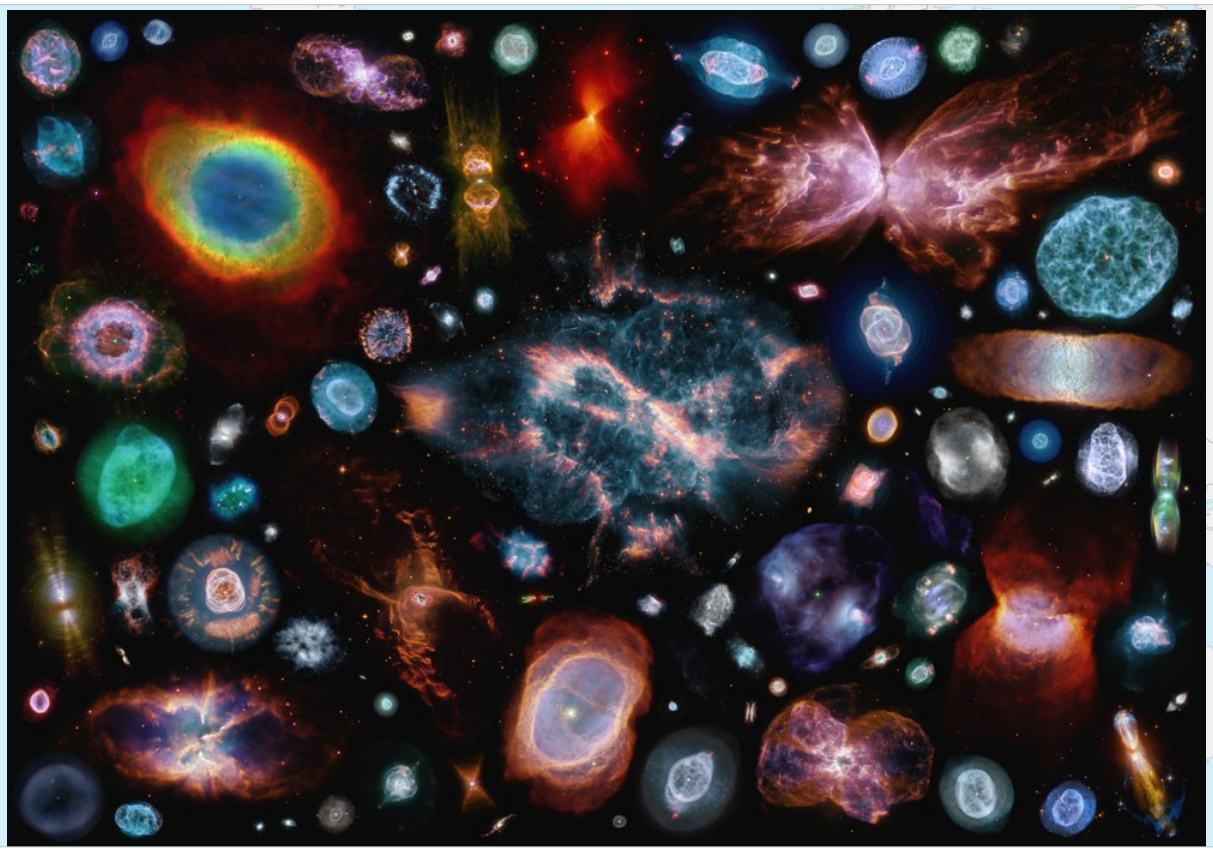


Formation of a PN









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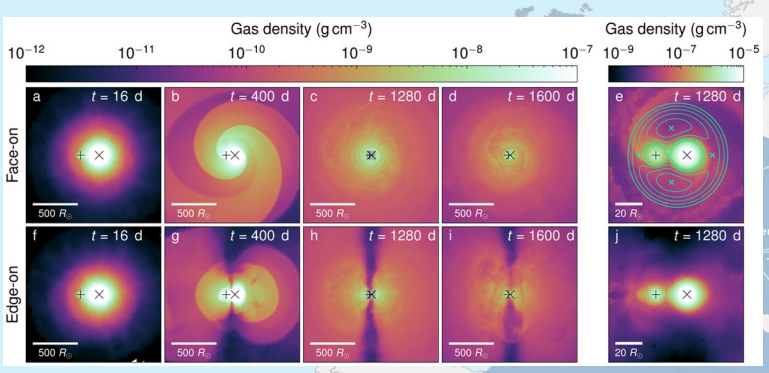

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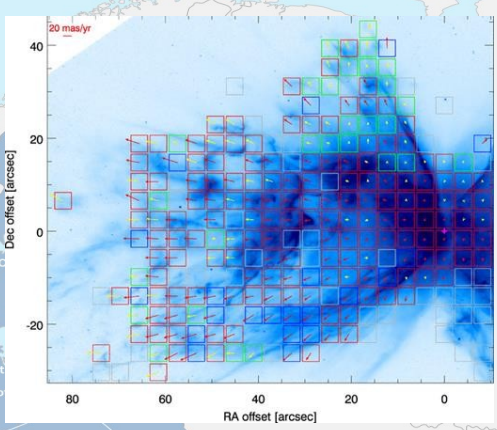

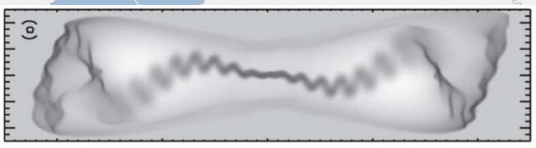

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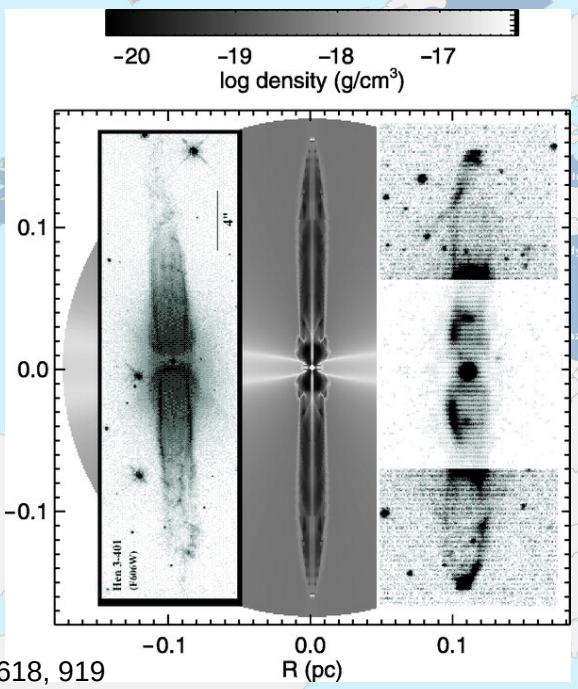
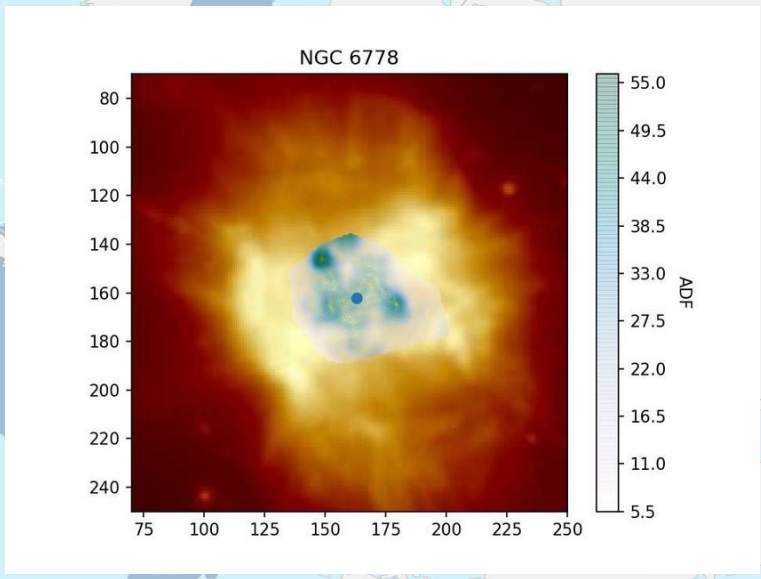
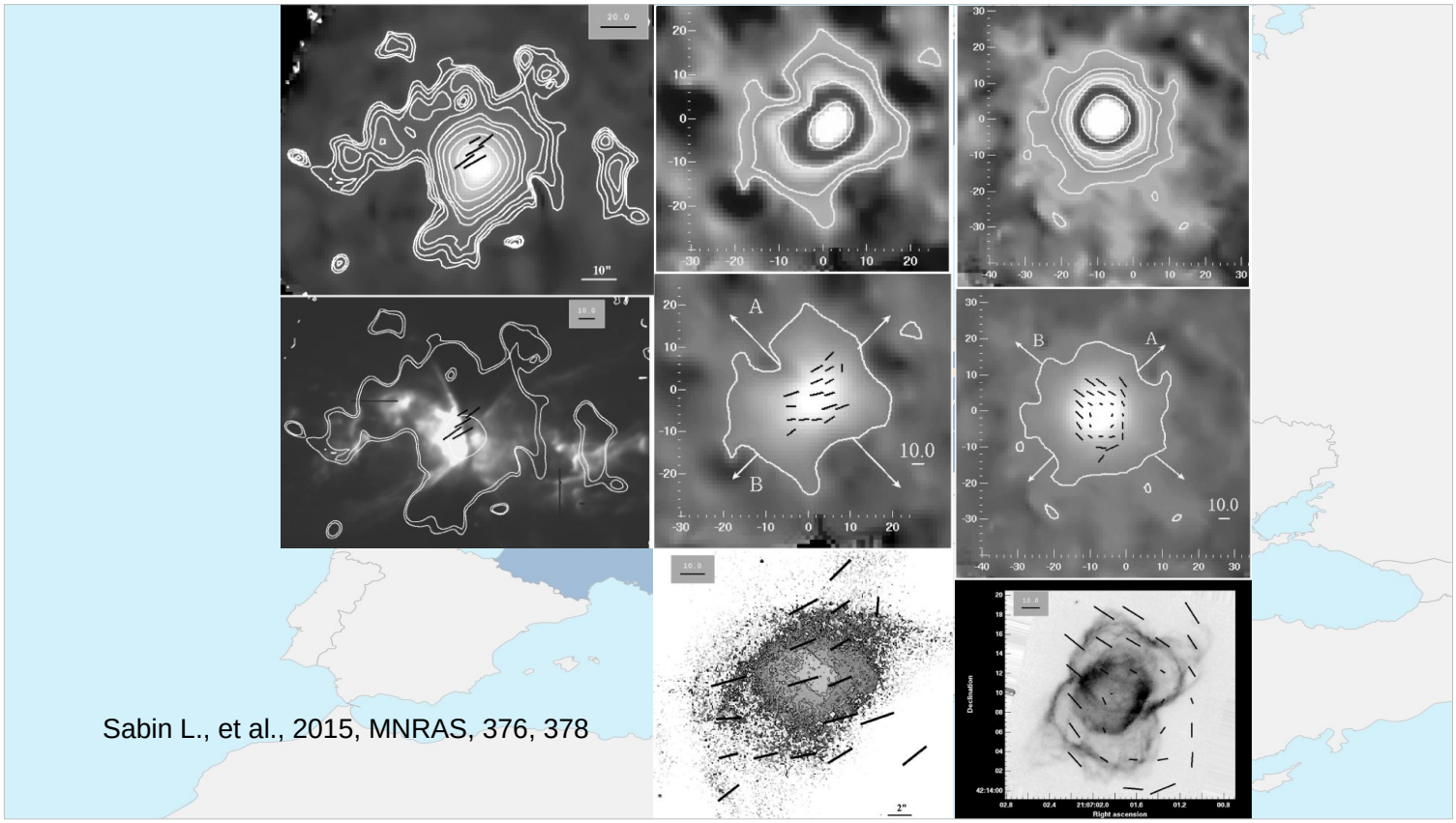


Garcia-Segura, G., et al., ApJ, 618, 919

Hot bubbles, cold blobs





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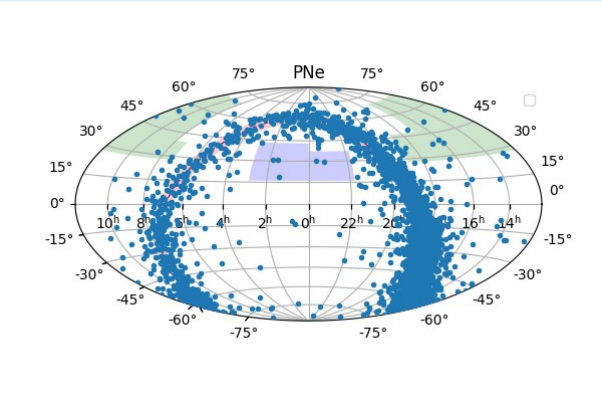
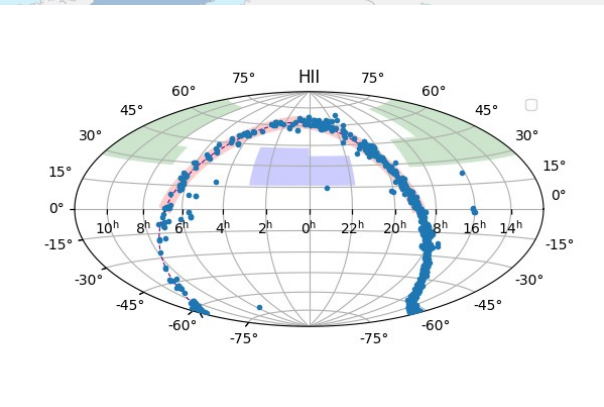
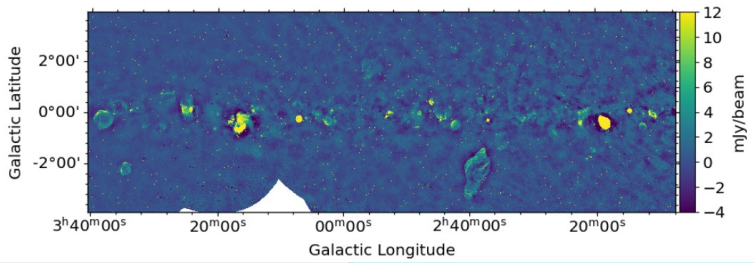
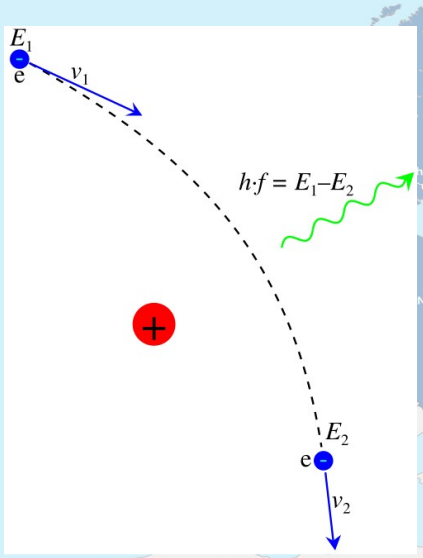
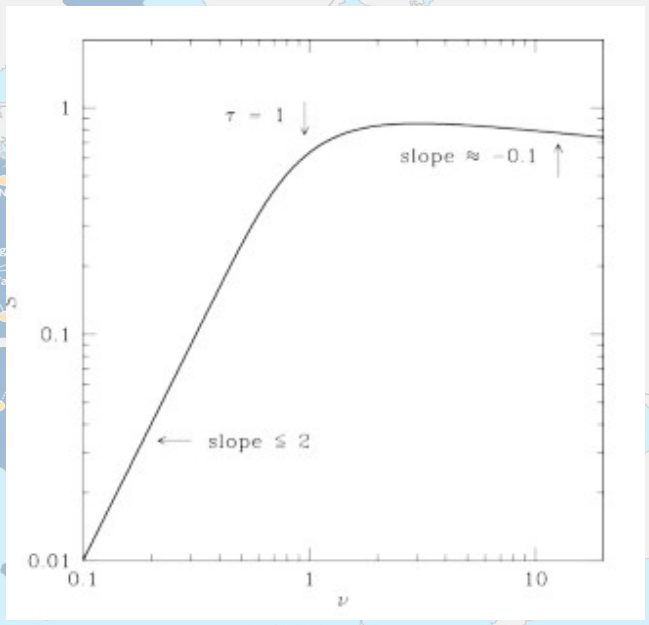




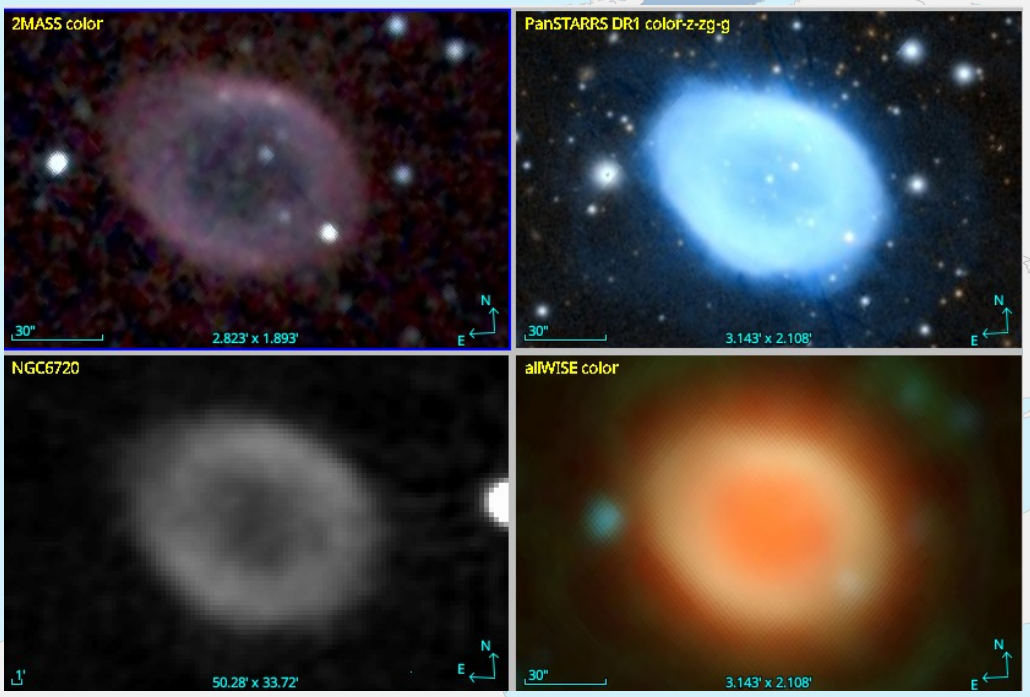


Thermal radio emission

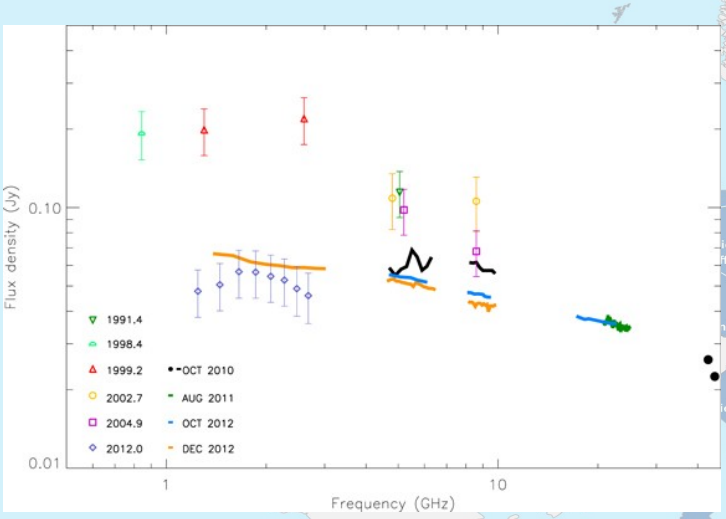




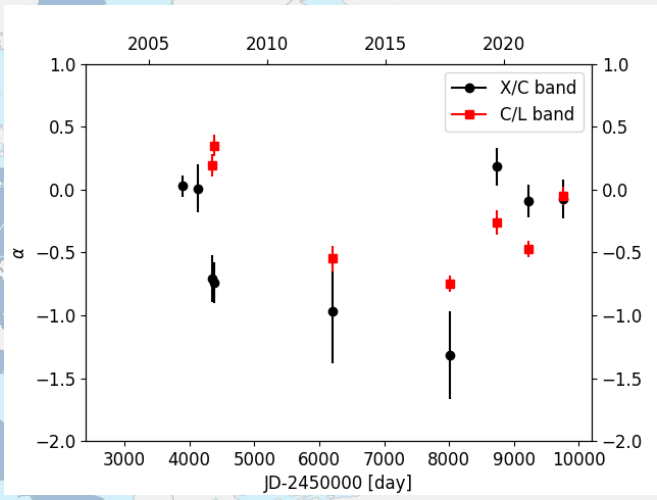
Ring nebula at different wavelengths



Non-thermal radio emission

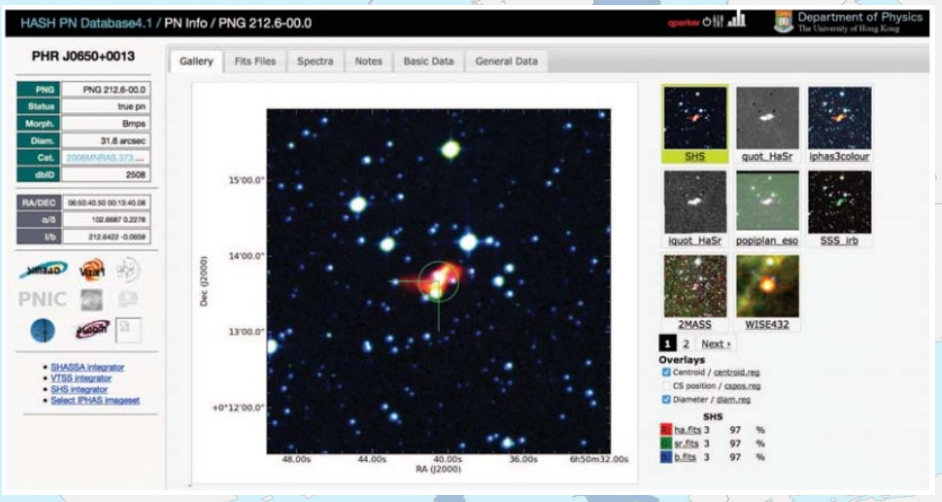


Suarez O., et al., 2015, ApJ, 806, 105



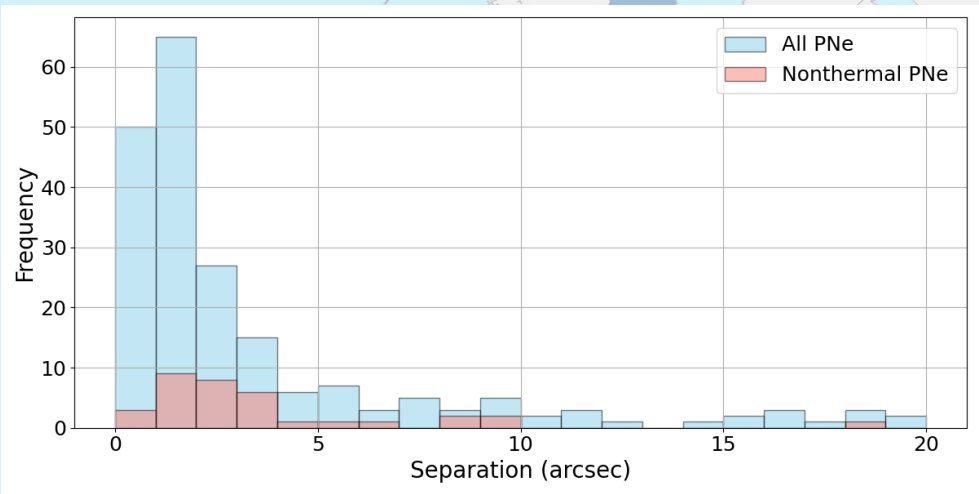
Hajduk, M., et al., 2024, A&A, 688L, 27

H-alpha Planetary Nebula (HASH PN) database, existing radio surveys

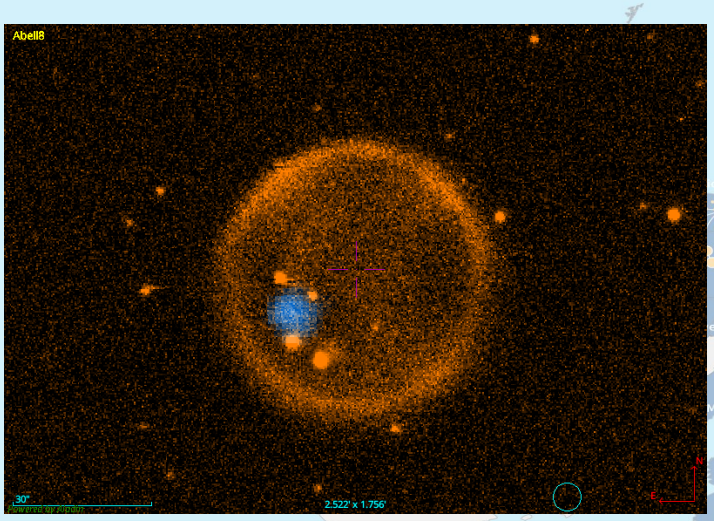


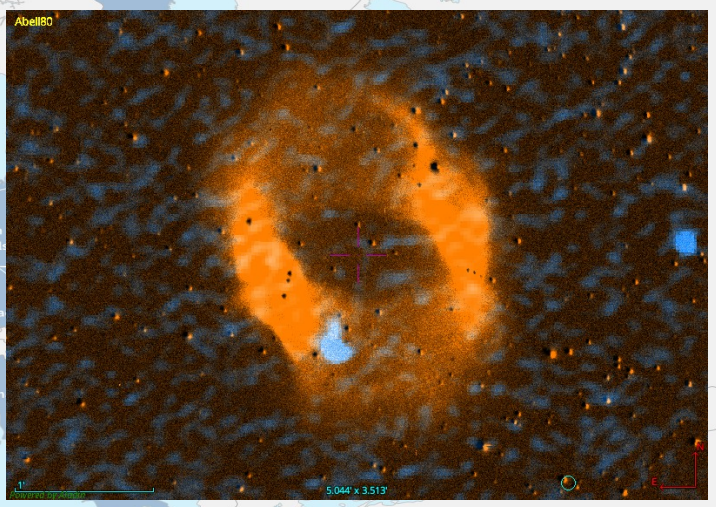
Parker Q., et al., 2016, JPhCS, 728, 2008

Identification of PNe in LoTSS

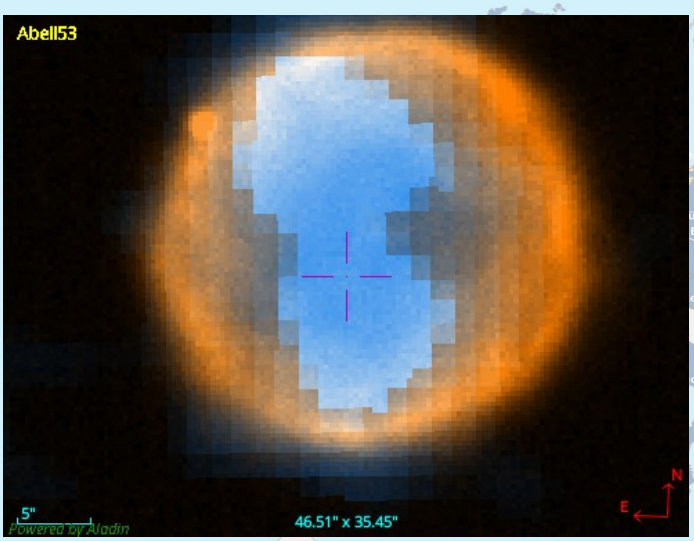


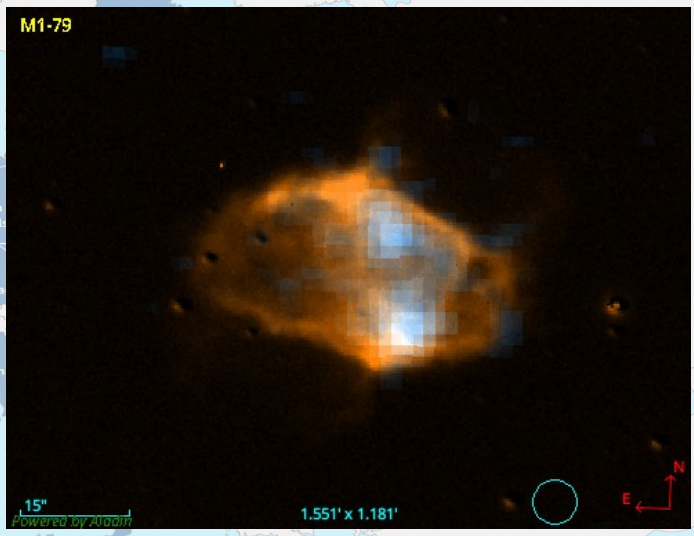
Additional verification



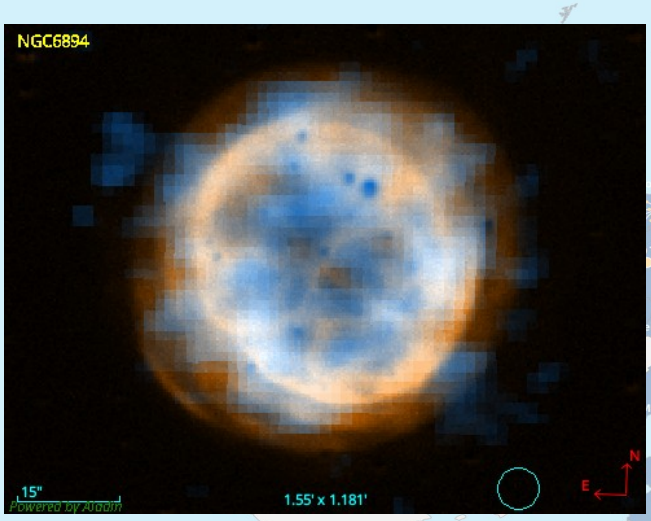


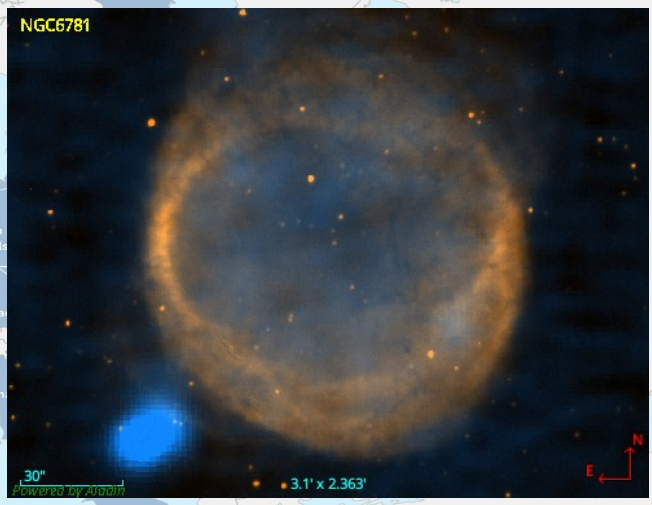
Bipolar radio emission



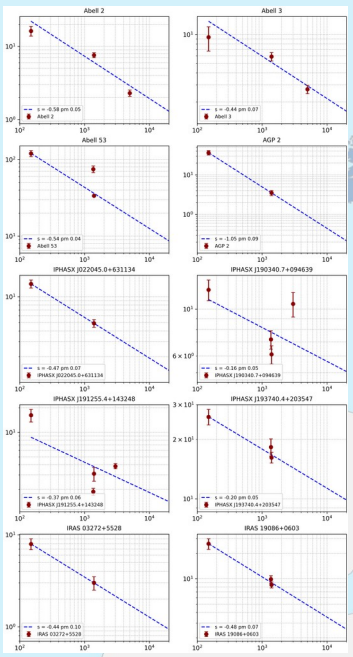


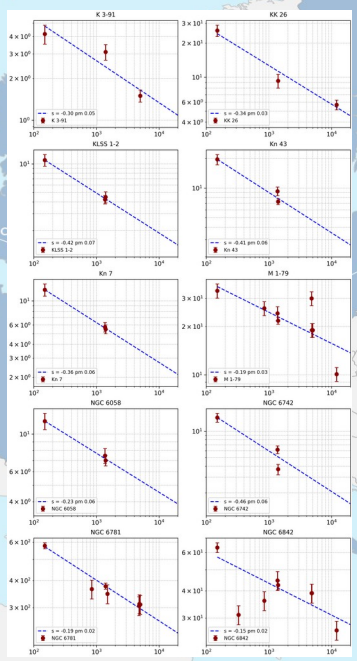
Radio emission filling nebula

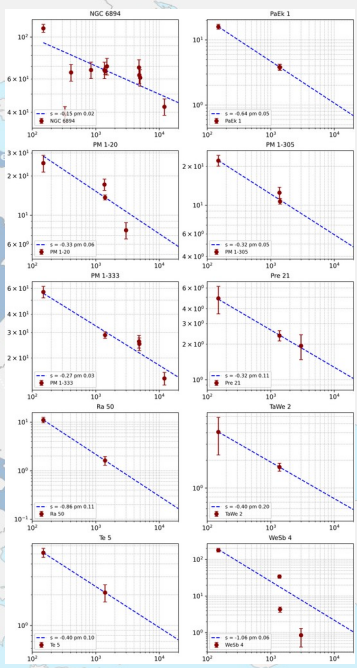




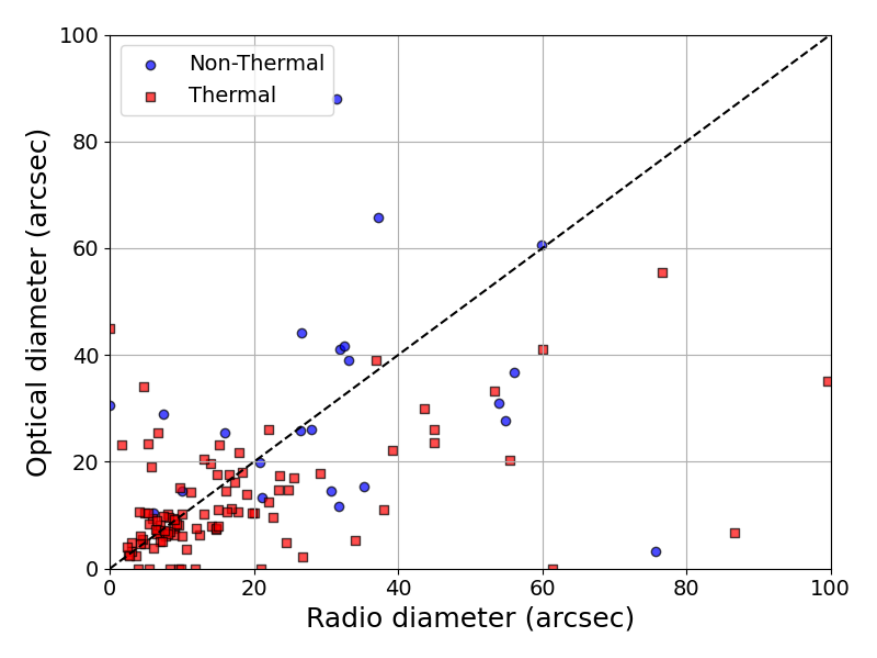
Radio spectra of non-thermal PNe



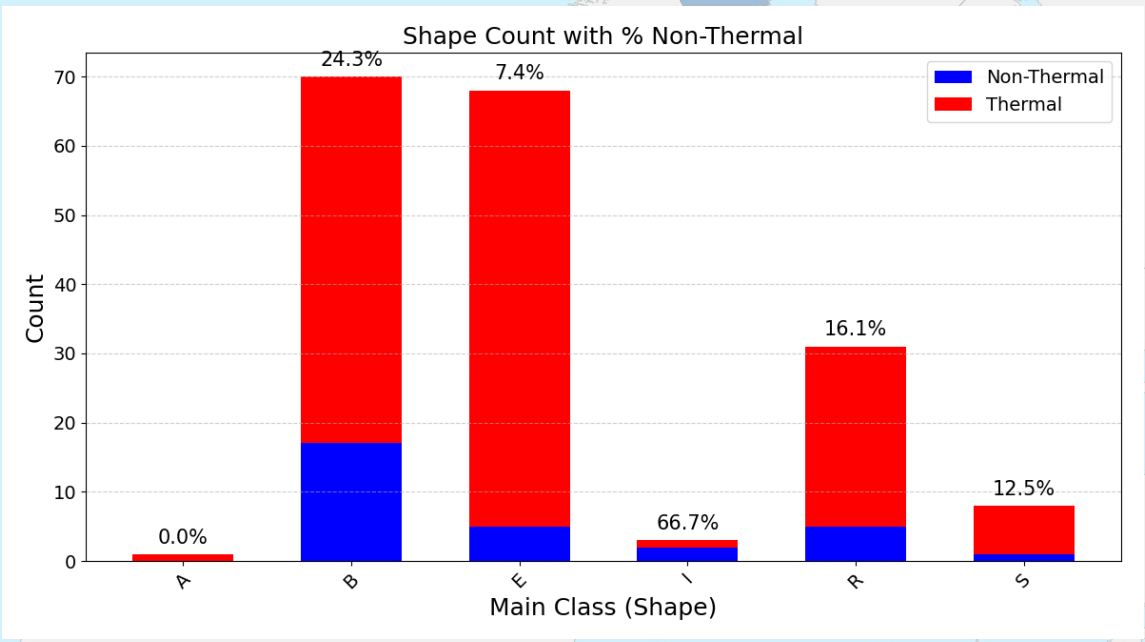




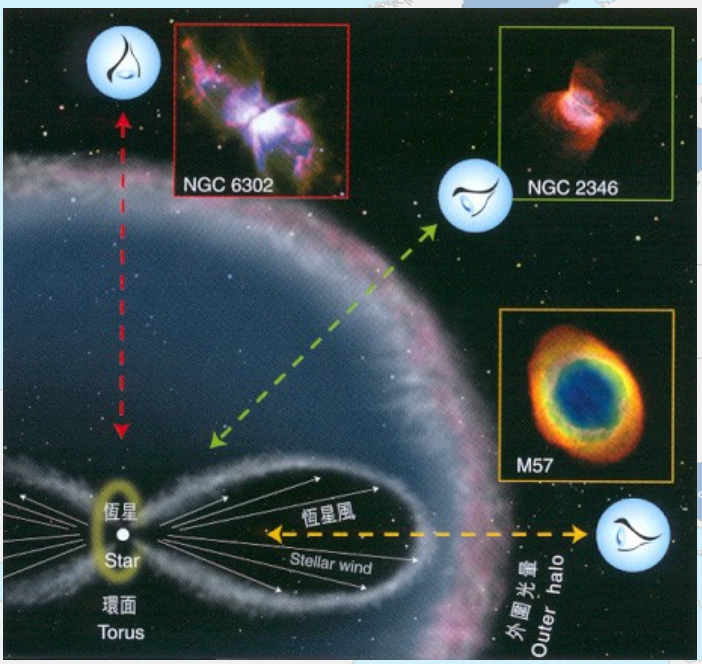
Type of emission vs size



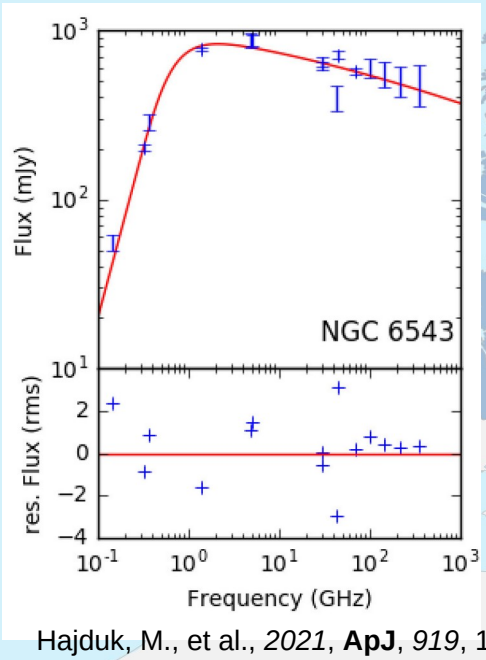
Occurence of non thermal emission vs morphology

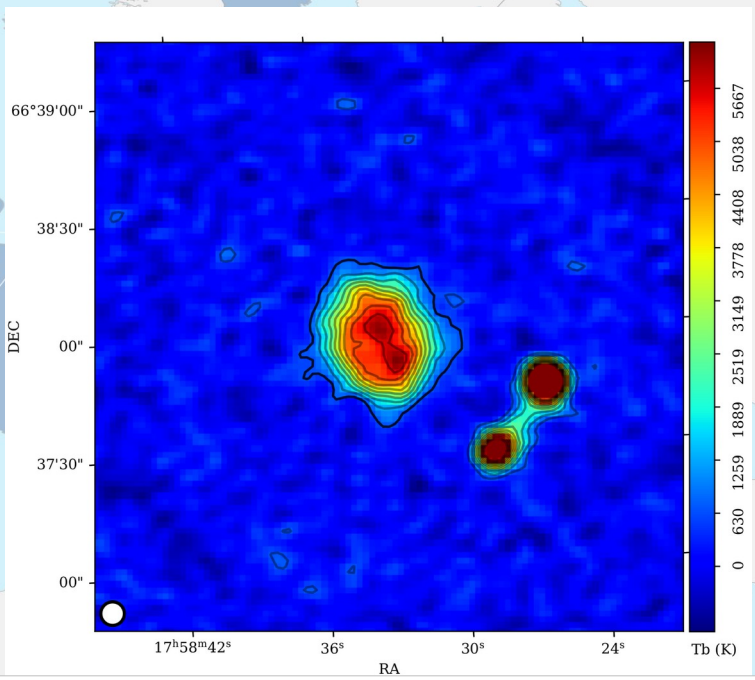


Projection effects



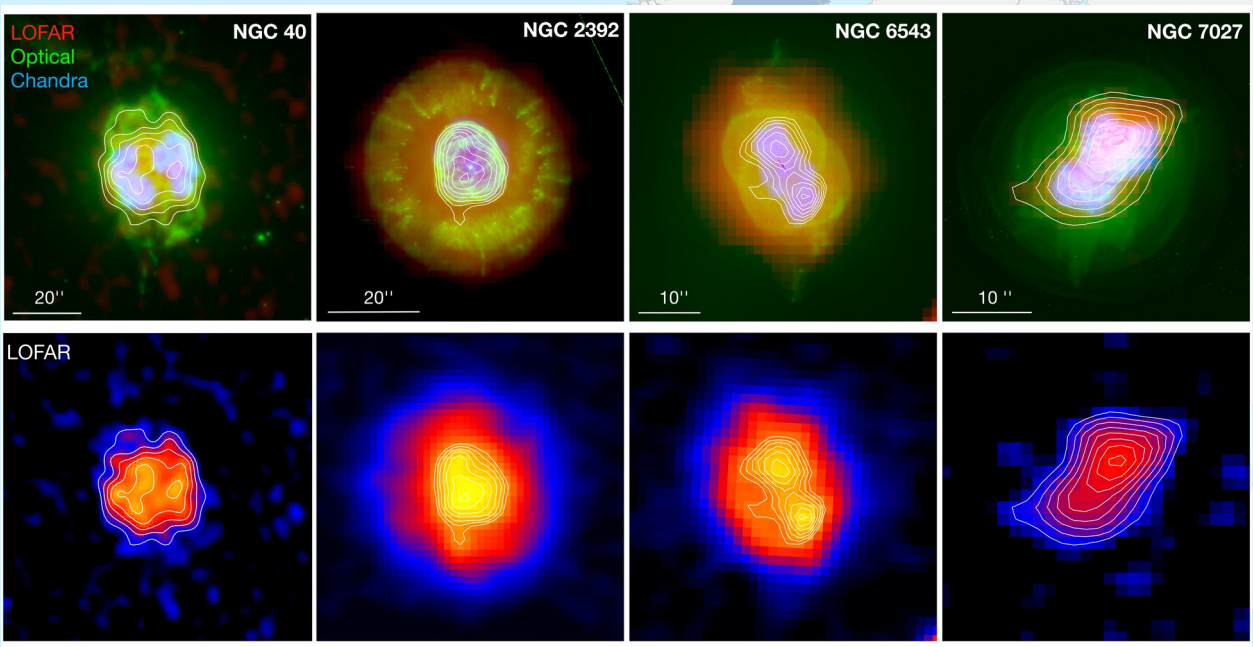
Mixed thermal and non thermal emission?



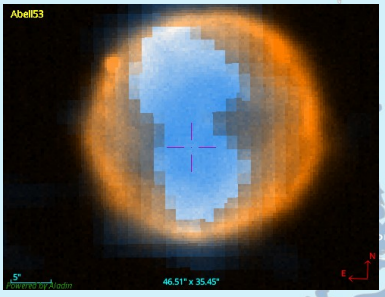


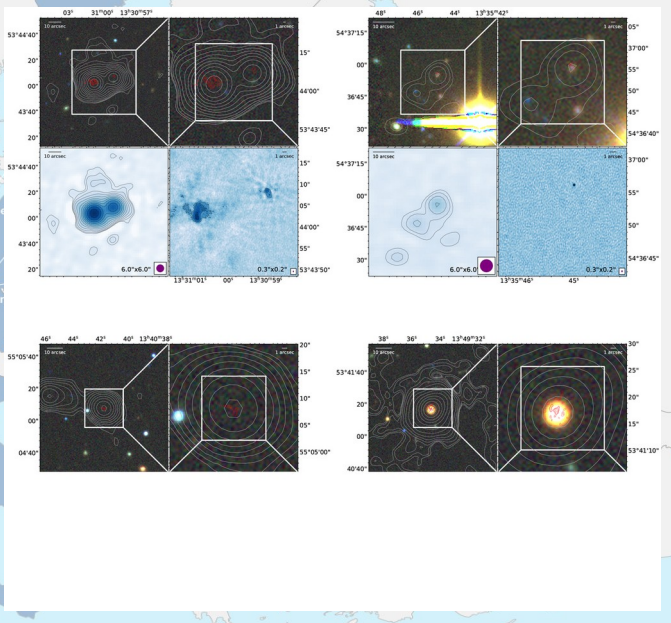
Hajduk, M., et al., *2021*, **ApJ**, *919*, 121

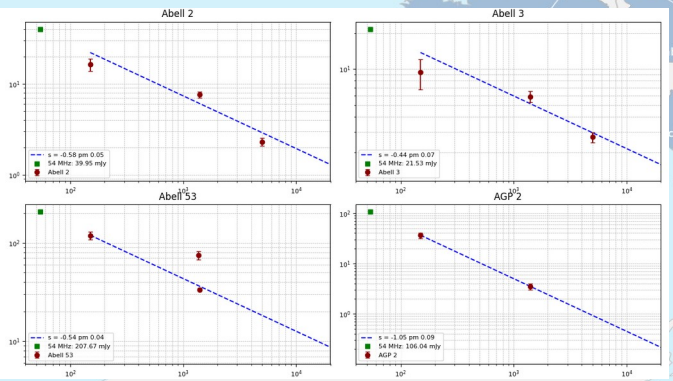
144 MHz excess correlated with X-ray emission



VLA P-band @350MHz or/and LOFAR VLBI or/and LBA







Morabito, L., et al., 2022, 658, 1