The Milky Way disk radial gradient from planetary nebulae reveled by Gaia

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Radial abundance gradients in the disk: are one of the most important observational constraints to study the chemical evolution of the spiral galaxies.

Oring of the gradient: it is the result of many physical processes that occur since the formation of a galaxy, as e.g. the infalling gas to form the disc, the star formation history, radial gas flows and the radial migration of stars.

Planetary nebulae (PNe): resulted from the evolution of low and intermediate-mass stars consisting of an expanding, glowing shell of ionised gas ejected from red giant stars late in their lives.

Problem #1: PNe distances are subject of great uncertainties, since, unlike main sequence stars, these objects do not have a physical parameter that is direct dependent of the distance.

Solving problem #1: By obtaining the distances to the PN's central star (CSPN) using the Gaia DR3 archive we can derive the Milky Way's radial abundance gradient with better accuracy. **Spoiler:** below the gradient obtained in this work.

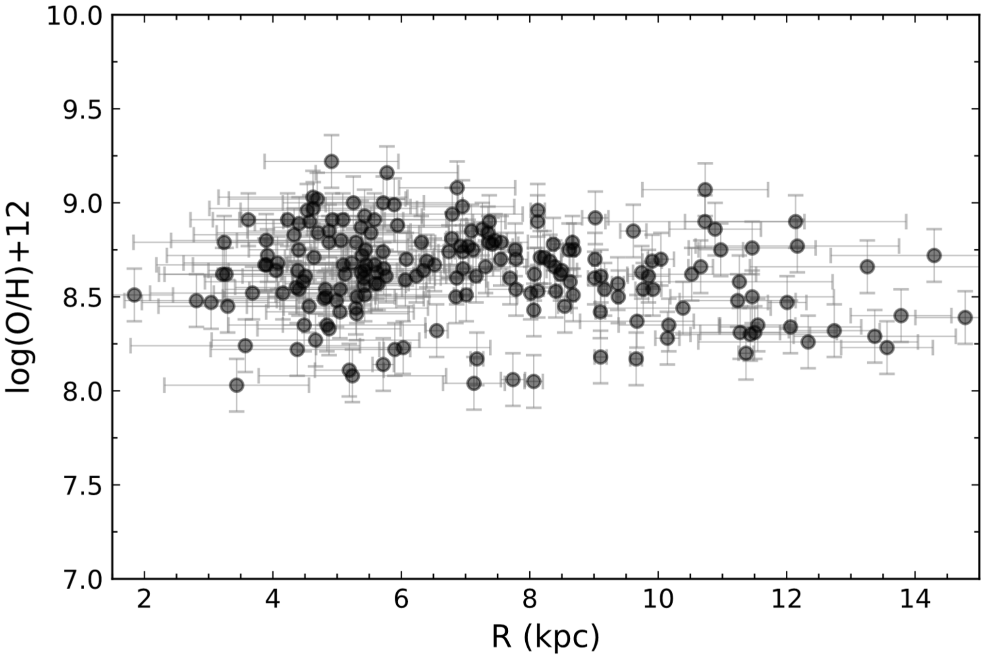


Fig. 1: Spoiler! The Milky Way's radial gradient as reveled by the Gaia DR3 distances.

Problem #2: In extended PNe there are multiple Gaia sources corresponding to the PN's coordinates, as exemplified in the image below. Which one is the central star of the planetary nebulae (CSPN) ?

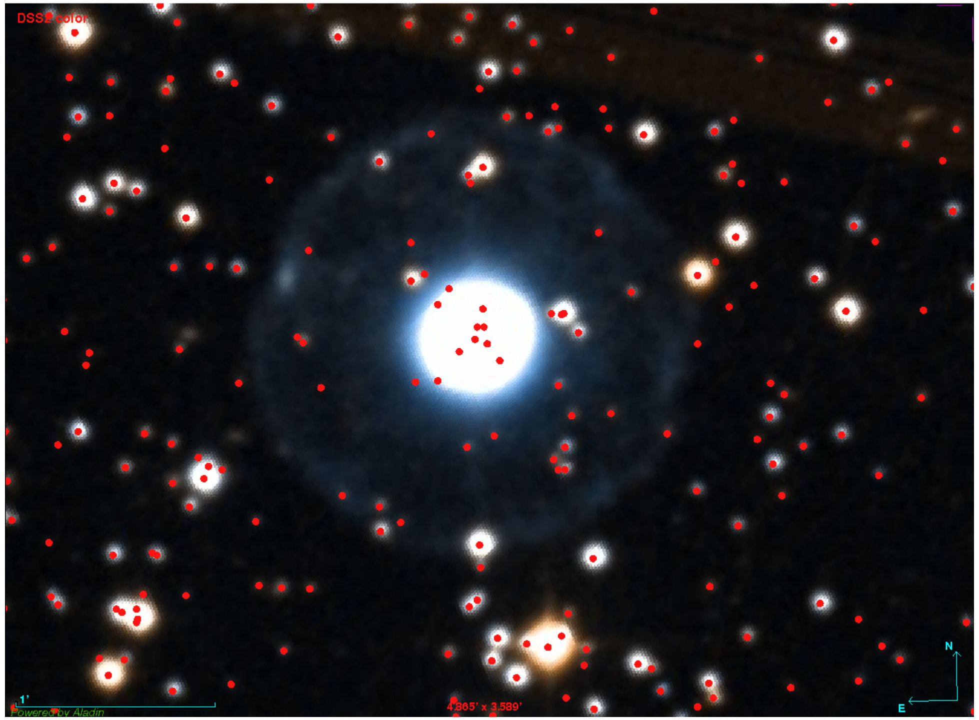


Fig. 2: Image of the PN NGC 6826 and Gaia sources as red circles. Source: Aladin.

Solving problem #2: We inferred the probability that the Gaia source is the CSPN by:

- Computing the distance to the central coordinate of the PN;
- Calculate the Gaia source surface temperature (T_{eff}) from the dereddened G_{BP} - G_{RP} color using the relation T_{eff} x (G_{BP} - G_{RP}) provided by Jordi et al. (2010).
- Higher probabilities were assigned to sources that were closer to the geometric center of the PN and with T_{eff} > 13 000 K.

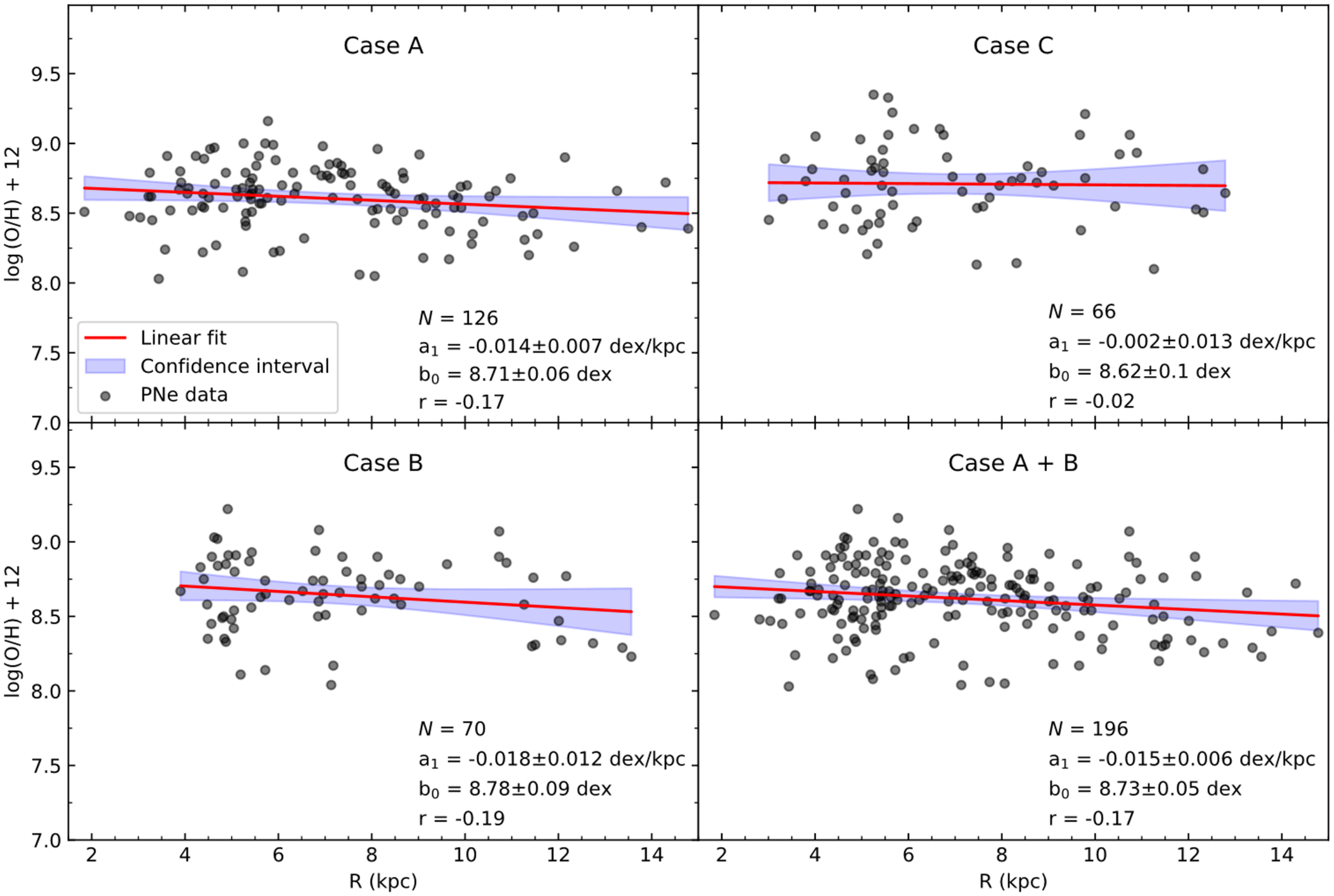
Probability to be the CSPN:

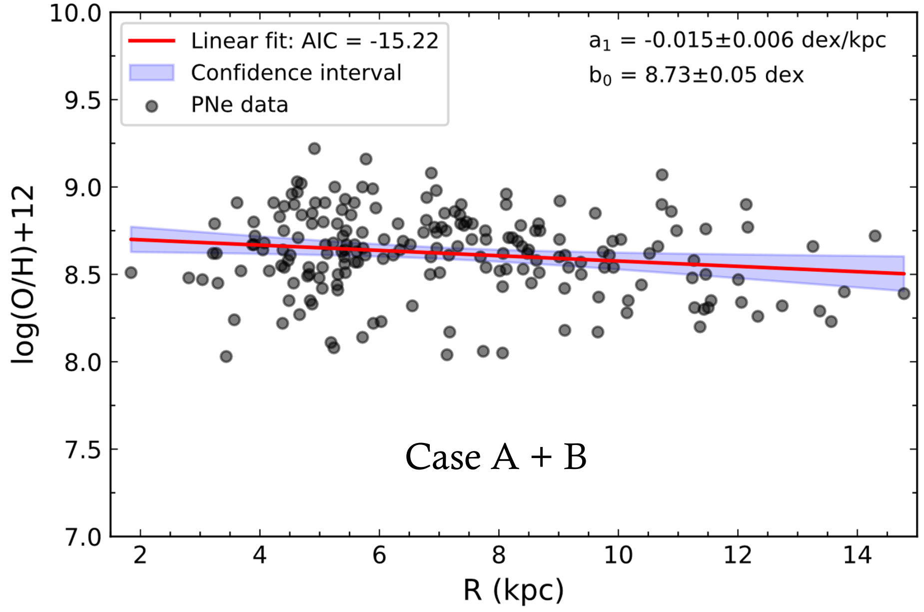
Case A (high probability): G_{BP} - G_{RP} < –0.2 and angular distance to the center of the PN lower than 20% of the PN radius.

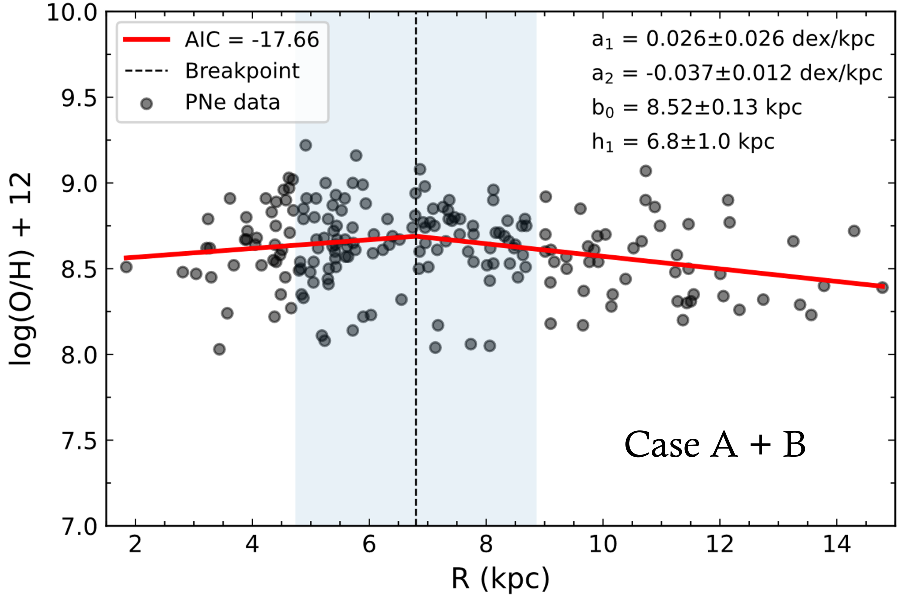
Case B (medium probability): G_{BP} - G_{RP} > –0.2 and angular distance to the center of the PN higher than 20% of the PN radius.

Case C (low probability): no G_{BP} - G_{RP} color information.

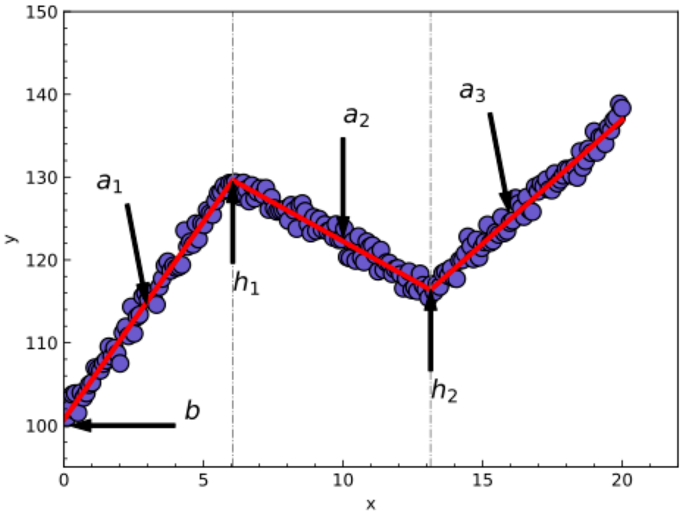
Chemical abundances from PNe:
They have very intense optical emission lines
and some elements observed
in PNe are not modified during the progenitor star evolution,
making then
important tools to probe the Galactic chemical evolution.
Chemical abundances used in this work are from Maciel et al. (2017) and Maciel et al. (2018) .







- Piecewise regression with one break radius.
- Akaike information criteria (AIC) to access the relative quality of statistical models.
- Statistically the fit with one break is the high-quality model (lower AIC).



- The principal radial gradient of - 0.037 dex/kpc agrees with recent determinations in the literature (Arellano-Córdova et al. 2020).
- The break occurs at R = 6.8 ±1.0 kpc.
- The break position is coincident with Milky Way's corotation radius of 8.51±0.64 kpc (Dias et al. 2019).