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Gas properties in the disc of NGC 891 from *Herschel* FIR spectroscopy

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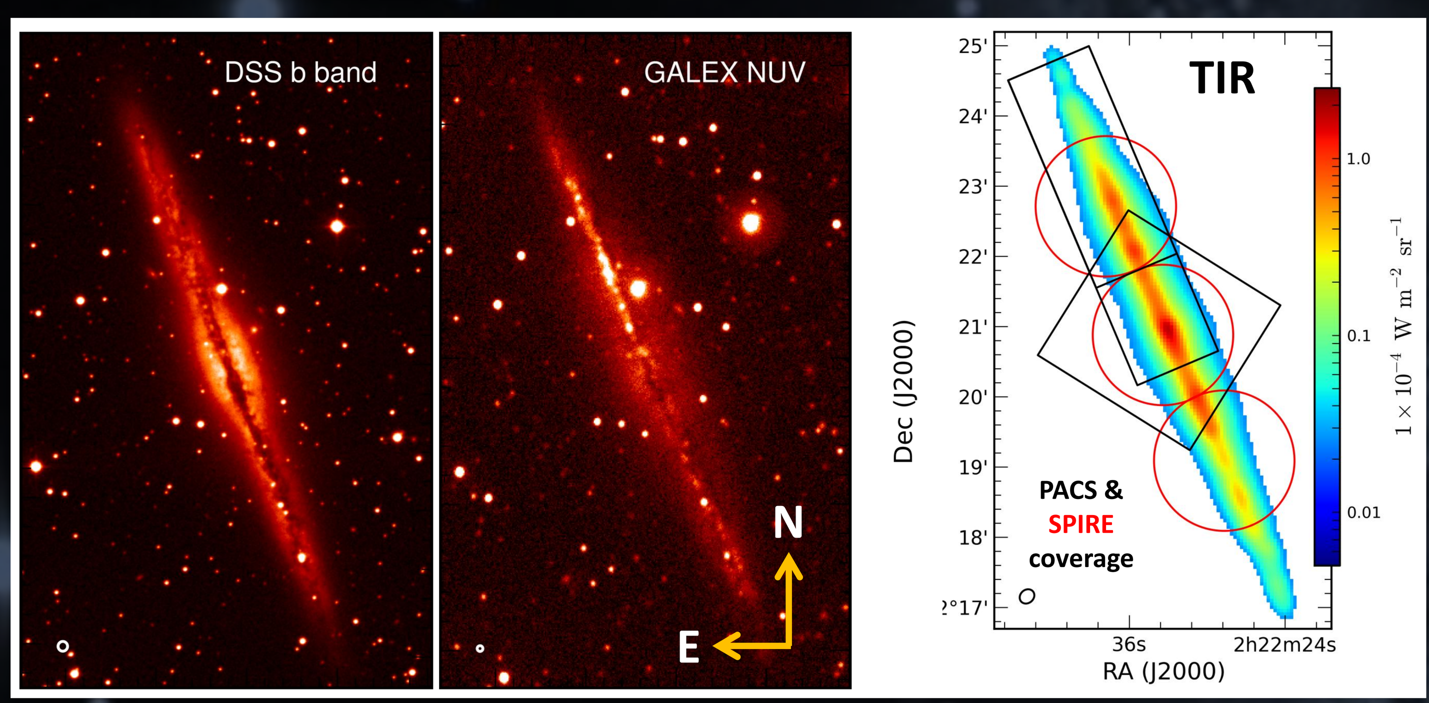
Abstract

We investigate the physical properties of the interstellar gas in the nearby edge-on spiral galaxy, NGC 891. We probe the heating and cooling processes on sub-kiloparsec scales using observations of the most important far-infrared (FIR) cooling lines obtained with the Herschel PACS and SPIRE instruments. We compare the FIR cooling line and total IR emission with the predictions from a photo dissociation region (PDR) model to determine the gas density (n), surface temperature (T), and the strength of the incident far-ultraviolet radiation field (G_0). A pixel-by-pixel analysis, resolving details on physical scales of 0.6 kpc, reveals the majority of the PDRs in NGC 891's disc have hydrogen densities and experience FUV radiation field strengths that are similar to the physical conditions found in the spiral arm and inter-arm regions of the face-on M51 galaxy. We estimate that the FUV field is stronger on average in the far north-eastern side compared to the rest of the disc, coinciding with above average star formation rates and gas-to-dust ratios, yet a conclusive interpretation remains difficult due to observational uncertainties.

1. NGC 891

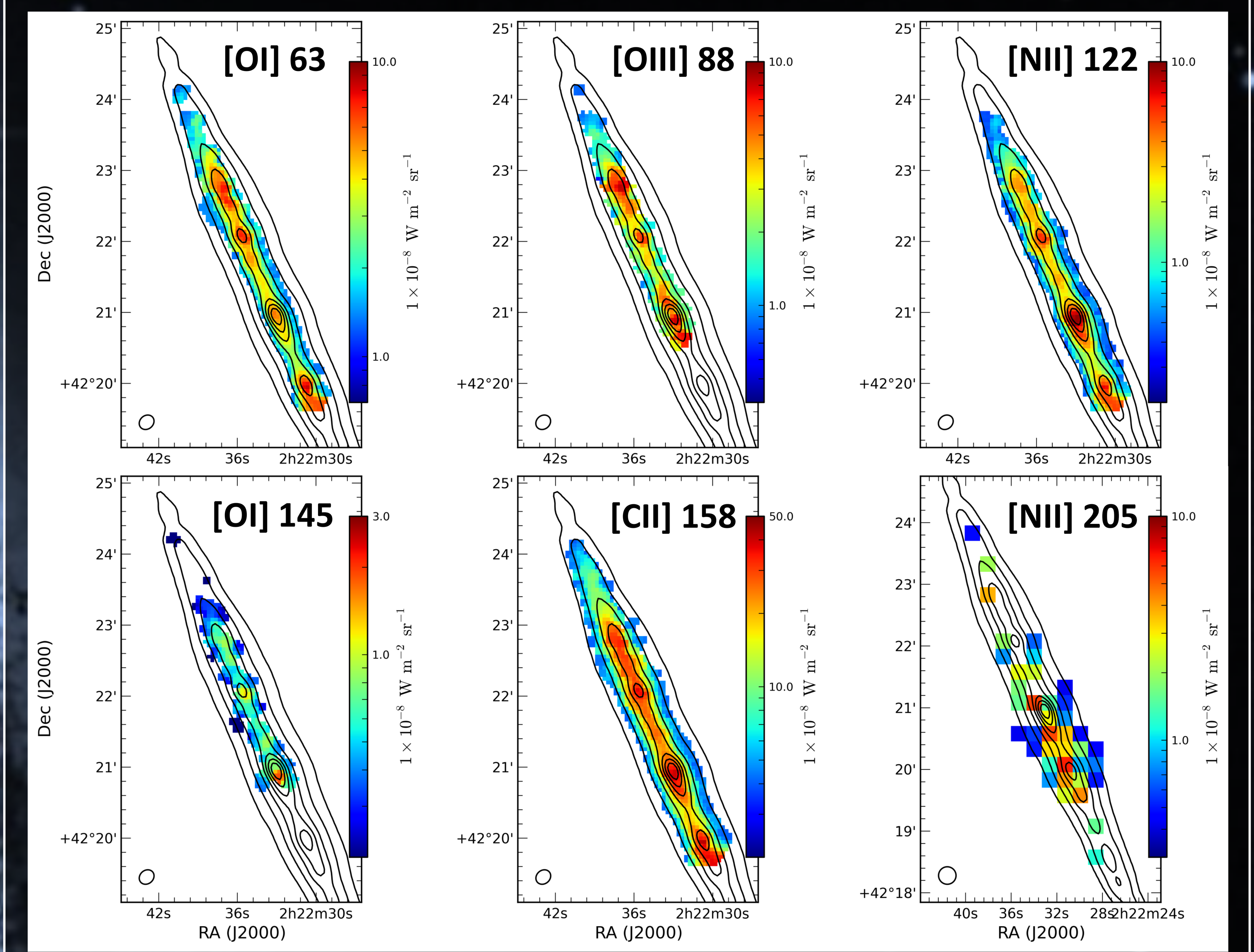
A nearby edge-on spiral galaxy with properties analogous to our Milky Way.



Studying the gas properties may shed light on whether an asymmetry in the NE is due to enhanced SF (Rossa et al. 2004) or dust obscuration of HII regions via dust along the line-of-sight through a spiral arm (Kamphuis et a. 2007).

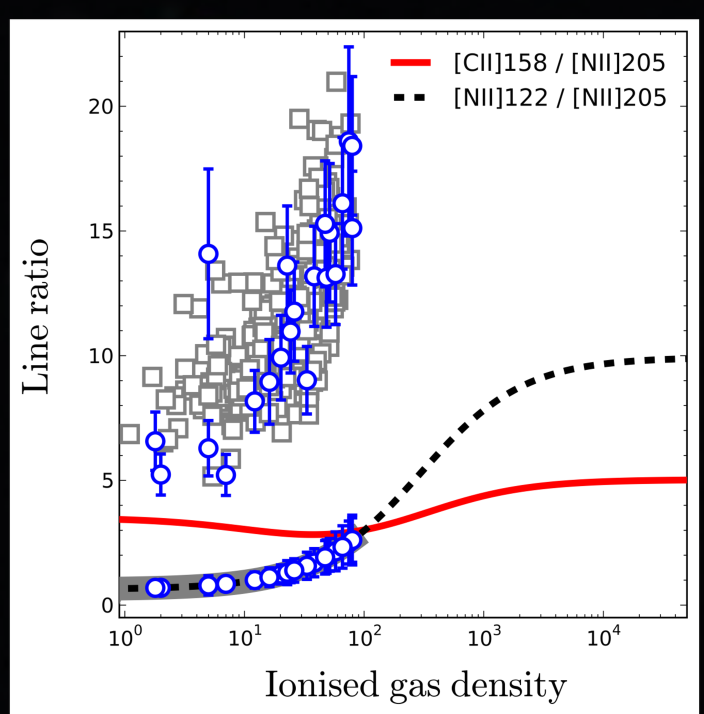
2. *Herschel* PACS / SPIRE observations

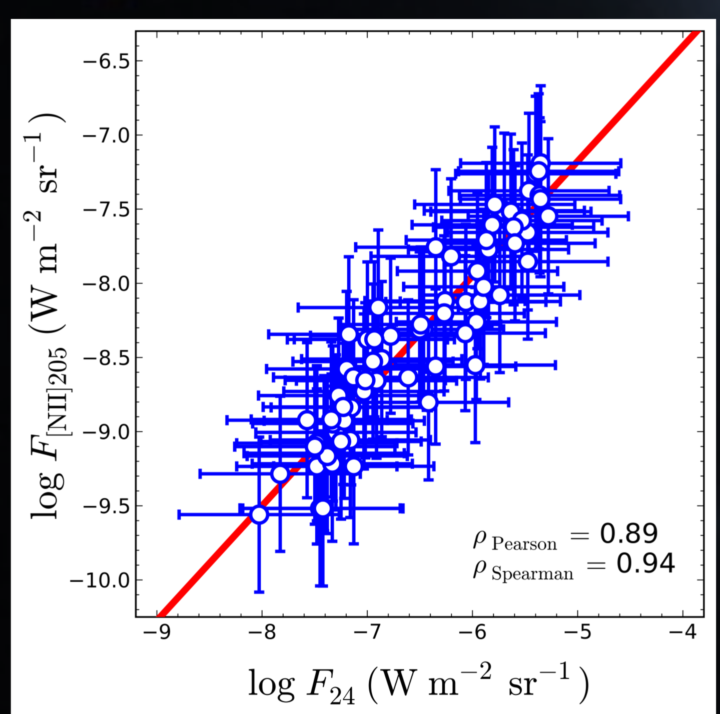
Observations of the main FIR fine-structure lines were taken as part of the Very Nearby Galaxies Survey (P.I.: C. Wilson). Contours follow the TIR map. All lines are from PACS, except for the [NII] 205 µm line from the SPIRE FTS.



3. What fraction of [CII] originates in ionised gas?

PDR models require the [CII] emission be corrected for an ionised gas component, which we estimate by inferring the gas density from the observed [NII]122/[NII]205 line ratio and then comparing the corresponding theoretical (red line) and observed [CII]/[NII]205 emission (blue circles).





Missing [NII]205 emission is estimated from a linear relation with 24 µm emission, increasing pixels with [CII] corrected for ionised gas (grey squares).

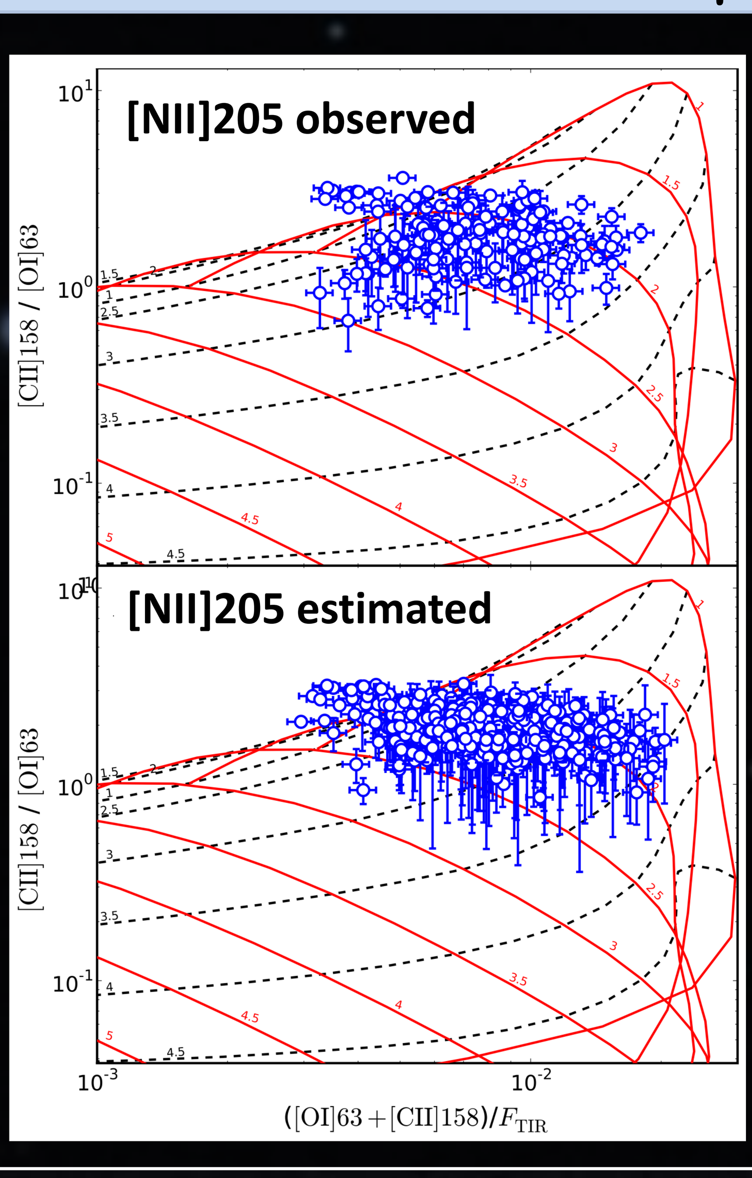
4. Photo dissociation regions

We adopt the model of Tielens & Hollenbach (1985), updated by Kaufman et al. (1999, 2006), which describes the PDR regions as semi-infinite, plane-parallel slabs of hydrogen, characterised by two parameters:

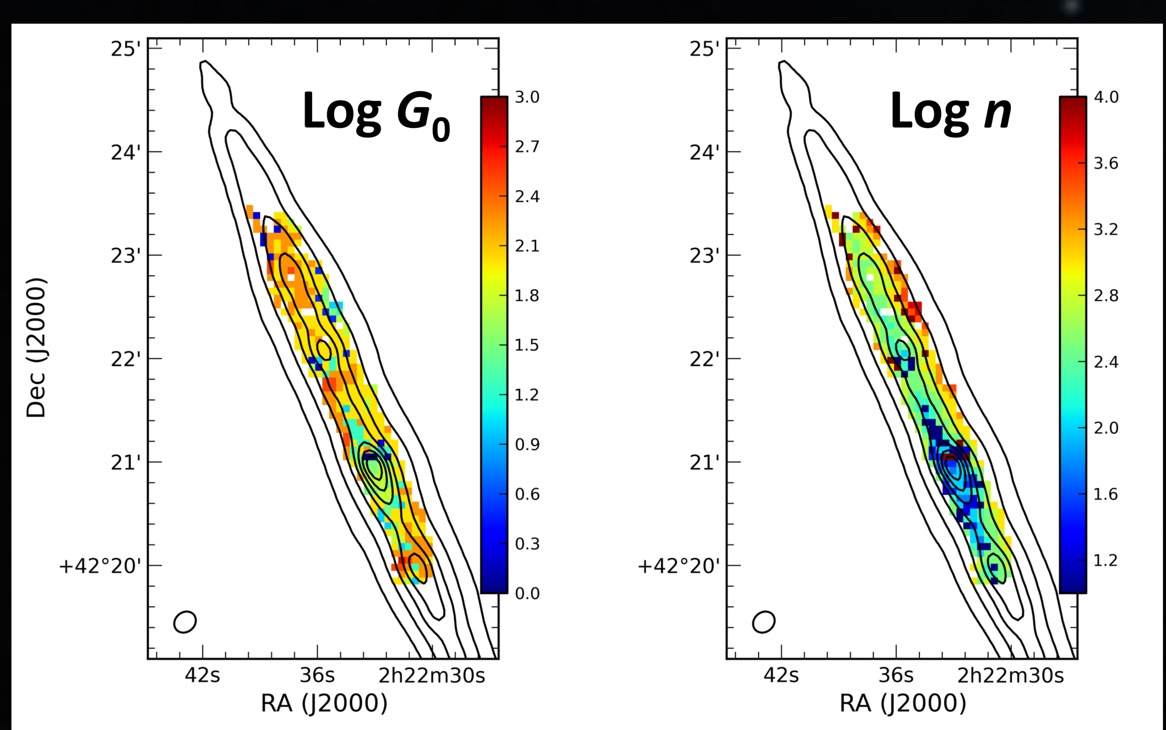
- G_0 - the strength of the incident FUV radiation field at the slab
- n - the density of hydrogen nuclei in the slab

We apply the model using the PDR Toolbox (http://dustem.astro.umd.edu).

5. Gas properties from PDR modelling



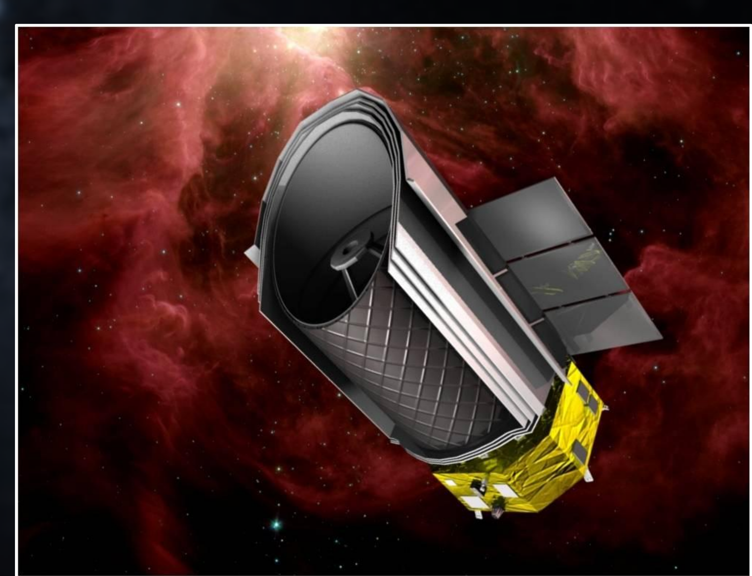
We compare the observed [CII]158, [OI]63, and TIR emission in each pixel to contours of constant FUV field strength (red lines) and hydrogen density (black lines) predicted from the PDR model of Kaufman et al. (2006).



For the first time, we construct maps of G_0 and n in NGC 891.

6. Conclusions

Our results suggest that the majority of PDRs in NGC 891's disc have hydrogen densities and experience FUV radiation field strengths that are similar to the physical conditions found in the spiral arm and inter-arm regions of the face-on M51 galaxy (Parkin et al. 2013).



SPICA with SAFARI will be able to expand our observations to far larger samples of galaxies.

References: Kamphuis et al. 2007, A&A 471 L1; Kaufman et al. 2006, ApJ 644 283; Parkin et al. 2013, ApJ 776 65; Tielens & Hollenbach 1985, ApJ 291 722; Rossa et al. 2004, AJ 128 674

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