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A COMPREHENSIVE STUDY OF HIGH METALLICITY GIANT EXTRAGALACTIC H II REGIONS: CHEMICAL ABUNDANCES

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RESUMEN

Hemos realizado observaciones espectrofotométricas en el óptico e infrarrojo cercano de 15 regiones H II en las galaxias espirales NGC 628, NGC 925, NGC 1232 y NGC 1637. Dichas observaciones han sido realizadas con una amplia cobertura espectral y con una resolución suficiente para detectar y medir tanto las débiles líneas aurorales como las características de estrellas Wolf-Rayet (WR). Hemos derivado la temperatura electrónica en las regiones observadas con el fin de investigar la estructura de ionización de las mismas y la composición química del gas. De esta manera, hemos seleccionado de la muestra de Van Zee et al. (1998), aquellas regiones H II gigantes cuya metalicidad, obtenida a partir de calibraciones empíricas basadas en las líneas prohibidas del oxígeno, es solar o sobresolar.

ABSTRACT

We have made long-slit spectrophotometric observations in the optical and near infrared of 15 H II regions in different spiral galaxies (NGC 628, NGC 925, NGC 1232 and NGC 1637). These spectrophotometric observations were performed with a wide spectral coverage and at a resolution high enough to detect and measure both weak auroral forbidden lines and Wolf-Rayet features. Electron temperatures have been derived in order to investigate the ionization structure and to derive the chemical composition of the gas in these regions. Therefore, we have selected from the literature (Van Zee et al. 1998) those H II regions with solar or oversolar abundance, as deduced from empirical calibrations based on the optical oxygen forbidden lines.

Key Words: **GALAXIES: INDIVIDUAL (NGC 628, NGC 925, NGC 1232, NGC 1637) — H II REGIONS**

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For seven of the observed regions, H13, H3, H4, H5 (NGC 628); CDT1, CDT3, and CDT4 (NGC 1232), we have been able to measure reliable electron temperatures from different nebular-to-auroral line intensity ratios, which allows the derivation of accurate abundances following standard methods. In particular, the metallicities found for these regions (except CDT1), previously reported to be close to solar, are found to be lower by factors between 0.2 and 0.5 dex, the latter in the case of H13 and H3. For the rest of the regions, both an empirical calibration based on the sulfur emission lines and detailed modeling has been used to determine a mean oxygen content.

In the case of CDT1 (NGC 1232), this is the first time that it has been possible to derive the mean oxygen content in a high metallicity H II region following standard methods. The derived value is $1.10Z_{\odot}$. This region, together with the observed one in NGC 1637 (CDT1) (its oxygen abundance derived from detailed modeling), are the only two regions in the sample that can be considered as of high metallicity.

Another interesting result concerns the observed regions in NGC 925. These regions, near the nucleus of the galaxy, present several problems. Despite the observational errors, both the S_{23} abundance calibration and the discrimination method showed by Díaz & Pérez-Montero (2000), tend to confirm these regions to have an subsolar oxygen content (12+log(O/H) between 8.5 and 8.7). Certainly, these values point to a flatter abundance gradient across the disc of this galaxy.

Our observational results show that a mean S/O abundance ratio of ±0.2 dex around the solar value. Nevertheless, regions H13, H3 (NGC 628), and CDT1 (NGC 1232), with oxygen abundances differing almost by an order of magnitude, show a subsolar S/O abundance ratio. Hence, CDT1 in NGC 1232

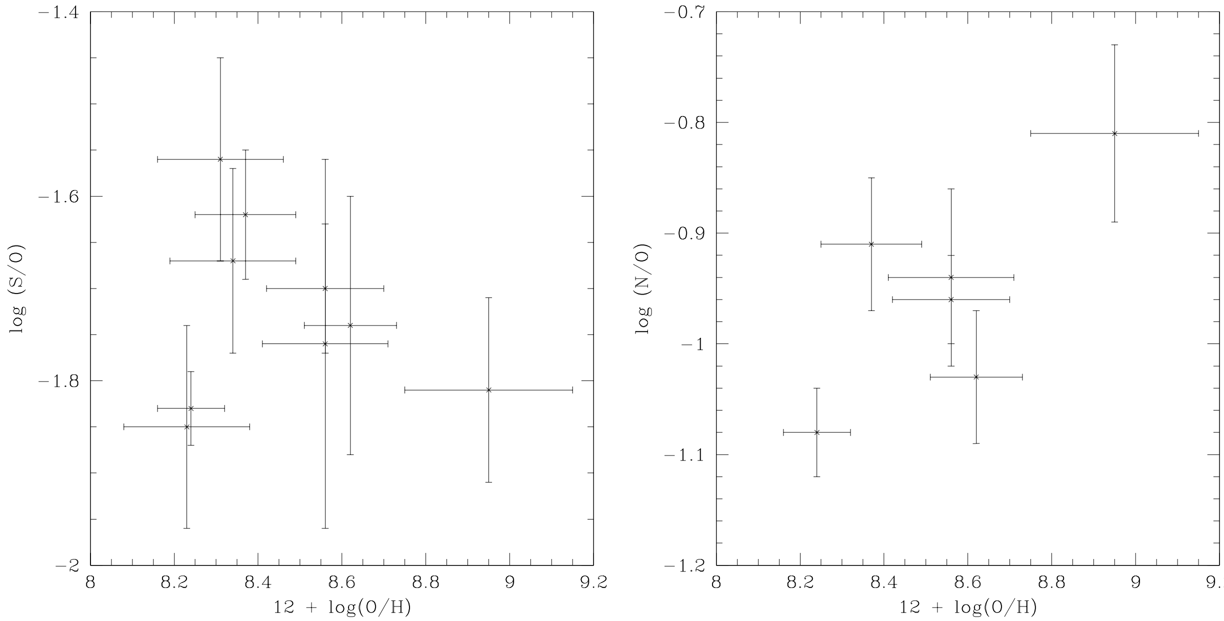

Fig. 1. S/O and N/O abundance ratios as a function of oxygen abundance in those regions where ion-weighted temperatures have been measured

shows the same trends as previously found by Díaz et al. (1991), from detailed modeling, for the observed high metallicity H II regions of M51. Regarding the N/O abundance ratio, all the observed regions show subsolar or solar values within the errors, except CDT1 (NGC 1232) where a direct value of -0.81 is obtained implying a secondary contribution of nitrogen as metallicity increases.

In the four observed GEHRs (H13, CDT1, CDT3, and CDT4). ion-weighted temperatures have been derived from different auroral to nebular line ratios. Our results show that mean ion-weighted temperatures from single-ionized atoms (N^+ and S^+) are higher than those corresponding to twice-ionized species (S^{2+}) for electron temperatures below 10 000 K. The derived values are in excellent agreement with predictions from single-star photoionization models (Garnett 1992). In the case of region H13, the mean value of the four measured electron temperatures is $10\,000 \pm 700$ K, and, again, models predict this isothermal behavior at 10 000 K. Moreover, by adopting the new effective collision strengths from Tayal (1997), several important discrepancies between $T(S^{2+})$ and $T(O^{2+})$ in other well studied GEHRs can be successfully removed. Therefore, Garnett's three-zone model nebula (Garnett 1992) seems to explain consistently the temperature stratification in H II regions.

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