RevMexAA (Serie de Conferencias), **9**, 234–235 (2000)

PHYSICAL PARAMETERS AND CHEMICAL COMPOSITION IN ABELL 78[1]

Selene Medina and Miriam Peña

Instituto de Astronomía,
Universidad Nacional Autónoma de México

RESUMEN

Se presentan los parámetros físicos y las abundancias químicas obtenidas de un estudio espectroscópico de alta resolución de A 78. Se estudiaron los nudos brillantes centrales y la cáscara externa rica en hidrógeno. Los nudos contienen un material extremadamente deficiente en hidrógeno; la composición de esta zona está dominada por helio y elementos pesados. La cáscara externa muestra hidrógeno y helio normales y parece tener muy baja metalicidad. Concluímos que la determinación de las abundancias puede estar afectada por la presencia de grandes fluctuaciones de temperatura en el gas, debidas a mecanismos de calentamiento adicionales tales como choques por material de alta velocidad y fotoelectrones de granos de polvo.

ABSTRACT

Physical parameters and chemical abundances were derived for different zones of A 78, from a high resolution spectroscopic study. The zones observed are the bright central knots and the outer hydrogen-rich shell. The knots contain an extremely hydrogen-deficient material and the composition of this zone is dominated by helium and heavy elements. The hydrogen-rich external shell appears to have normal helium abundance and very low metallicity. We conclude that the abundance determination is affected by the presence of large temperature fluctuations in the gas, due to additional heating mechanisms such as shocks by high speed ejecta and photoelectrons from dust grains.

Key Words: **ISM: ABUNDANCES — PLANETARY NEBULAE: INDIVIDUAL (A 78) — STARS: AGB AND POST-AGB**

Astrophysical Plasmas: Codes, Models, and Observations (Mexico City, 25-29 October 1999)
Editors: Jane Arthur, Nancy Brickhouse, & José Franco

1. INTRODUCTION

Abell 78 (A 78), together with Abell 30 and Abell 58 are the members of a small but important class of planetary nebulae, which are characterized by hydrogen-poor, dusty ejecta. In these objects the hydrogen-poor material is surrounded by an outer envelope of normal composition, indicating that a secondary ejection of highly processed gas has occurred after the loss of the H-rich envelope of the AGB progenitor. The central stars present helium and carbon emission line spectra. Leuenhagen, Koesterke, & Hamann (1993) have analyzed the stellar spectrum of A 78 by computing models of expanding atmospheres. They have derived an effective temperature of 1.15×10^5 K, a mass-loss rate $\log \dot{M} = -5.2\ M_\odot\ \mathrm{yr}^{-1}$, and a chemical composition of $\beta_{\rm He} = 33$, $\beta_{\rm C} = 50$, $\beta_{\rm N} = 2$, and $\beta_{\rm O} = 15$, in percentage of mass fraction.

Direct imaging of A 78 shows a complex nebular morphology: inner knots distributed in a flat structure around the central star and a knotty shell very bright in [O III] lines and faint in H lines, surrounded by a diffuse shell with bright H lines and faint [O III] emission. The central nebular zones show intense infrared emission indicating the presence of abundant dust.

Meaburn et al. (1998) have performed a detailed kinematical study of the nebula in the [O III] 5007 line, obtaining a radial expansion velocity of 40 km s^{-1} and a complex kinematical structure in the inner knotty

[1] Based upon data collected at Observatorio Astronómico Nacional, San Pedro Mártir, B. C., México.

TABLE 1

PHYSICAL PARAMETERS IN THE OBSERVED ZONES

Parameter	Inner knots	Outer shell	⟨ PN ⟩[1]
T_e (10^4 K)	1.88 ± 0.10	2.15 ± 0.20	
N_e (10^2 cm^{-3})	7.9 ± 2.6	1.0 ± 0.5	
He/H	1.17	< 0.12	< 0.12
O/H(10^{-4})	5.30	> 0.42	4.79
N/O	0.23	–	0.47
Ne/O	0.29	0.24	0.26

(1) Taken from Kingsburgh & Barlow 1994.

shell which shows high velocity structures (*spikes*) covering a velocity range from 0 to ±140 km s^{-1} relative to the shell.

Here we present the physical parameters and the chemical composition of the bright central knots and the hydrogen-rich envelope. A full description of this work has been submitted to A&A.

2. OBSERVATIONS AND DATA ANALYSIS

Calibrated spectra of the bright knots near the central star and the outer, hydrogen-rich shell of A 78 were obtained with the REOSC Echelle Spectrograph using the 2.1-m telescope at the OAN-SPM, México, covering the 3500–7360 Å range with a spectral resolution of about 0.2 Å per pixel. Physical conditions, T_e and N_e, were determined in the different nebular zones. The physical conditions were used for deriving ionic abundances. Total abundances were obtained from the ionic abundances and using the ionization correction factors given by Kingsburgh & Barlow (1994). The results are presented in Table 1.

3. RESULTS AND DISCUSSION

The inner knots appear to be denser and slightly cooler than the hydrogen-rich shell. The chemical composition of these knots indicates an extremely hydrogen-deficient material. The main elements are freshly-made helium and heavy elements which have been expelled from zones of the star where nucleosynthesis took place. On the other hand, the hydrogen-rich external shell appears to have normal He/H ratio and a very low metallicity compared to the average values found in galactic planetary nebulae. We conclude that the abundance determination is probably affected by the presence of large temperature fluctuations in the gas, due to additional heating mechanisms such as shocks by high speed ejecta and stellar winds, photoelectrons evaporated from dust grains, etc.

This work was partially supported by DGAPA/UNAM (grant IN-109696). S.M. acknowledges scholarship by DGEP/UNAM.

REFERENCES

Kingsburgh, R. L., & Barlow, M. J. 1994, MNRAS, 271, 257
Leuenhagen U., Koesterke L., & Hamann W.-R. 1993, Acta Astron. 43, 329
Meaburn J., López J. A., Bryce M., & Redman M. P. 1998, A&A 334, 670

S. Medina and M. Peña: Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México (selene,miriam@astroscu.unam.mx).