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Astrophysical Plasmas: Codes, Models, and Observations (Mexico City, 25-29 October 1999)
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PHOTOIONIZATION MODELS OF NGC 2363

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RESUMEN

Calculamos modelos de fotoionización para la región H II extragaláctica gigante NGC 2363, y los comparamos con datos observacionales ópticos. Mostramos que modelos calculados con el valor de metalicidad que se observa en la región ($Z = 0.10\ Z_\odot$) no reproducen el espectro observacional, y que el desacuerdo puede ser resuelto suponiendo fluctuaciones espaciales de temperatura en la nebulosa. Mostramos que la metalicidad de NGC 2363 ha sido subestimada, y que un valor de $Z \simeq 0.25\ Z_\odot$ está en mejor acuerdo con los datos observacionales, respecto al valor comúnmente adoptado de $Z \simeq 0.10\ Z_\odot$.

ABSTRACT

We compute photoionization models for the giant extragalactic H II region NGC 2363, and compare them with optical observational data. We show that models computed with the observed metallicity of the cluster ($Z = 0.10\ Z_\odot$) do not reproduce the observed features of the spectrum, and that the disagreement can be overcome by allowing for spatial temperature fluctuations in the nebula. Accordingly, we show that the metallicity of NGC 2363 has been underestimated, and that a value of $Z \simeq 0.25\ Z_\odot$ is in better agreement with the observational data than the usually adopted value $Z \simeq 0.10\ Z_\odot$.

Key Words: **GALAXIES: STARBURST — H II REGIONS — ISM: ABUNDANCES — STARS: WOLF-RAYET**

1. INTRODUCTION

In the present work we studied the star formation history and the chemical composition of NGC 2363, a very luminous giant extragalactic H II region, by means of a comparison between photoionization models, computed with version 90.04 of Cloudy (Ferland 1996) and the observed features of the emission spectrum (Izotov, Thuan, & Lipovetski 1997; González-Delgado et al. 1994; Peimbert, Peña, & Torres-Peimbert 1986).

Our models assume a spherical, hollow, radiation bounded nebula, made up of two concentric shells of different densities. The grid spans different cases for the star formation law, the initial mass function, the high mass cutoff of the IMF, the age of the cluster, the inner radius of the nebula, the electron density, the gas covering factor, the stellar metallicity, and the gas metallicity. The ionizing spectra have either been taken from Leitherer et al. (1996), or have been recomputed with the same synthesis code. To compare the model results with the observed line intensities, we corrected the standard model output for the size of the slits used in the three works mentioned earlier.

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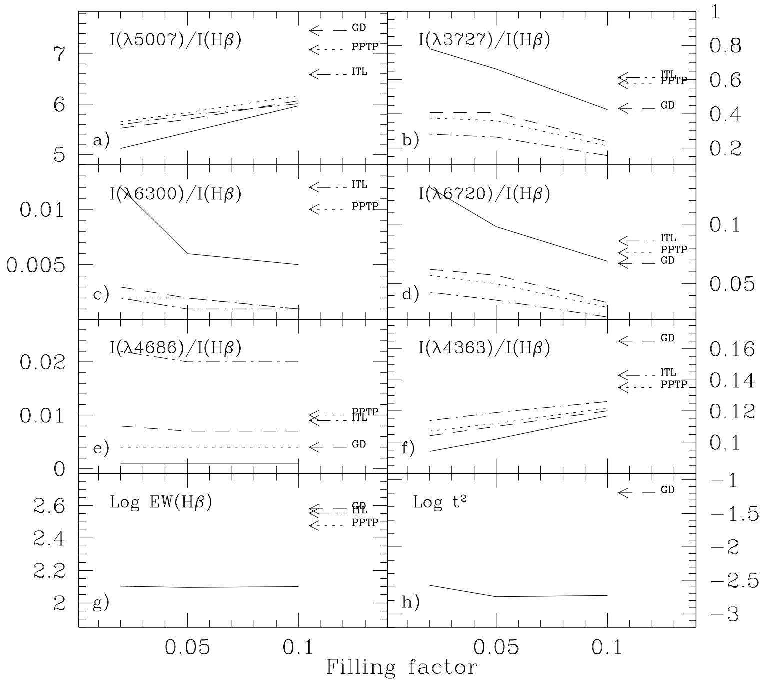

Fig. 1. Intensity ratios (panels *a* to *f*), equivalent width of Hβ (panel *g*) and t^2 (panel *h*) as a function of the filling factor, for a sequence of models with $Z_* = 0.10\ Z_\odot$, $Z_{gas} = 0.08\ Z_\odot$. Panels *a-f*: complete model (*solid line*), Slit A (*long-dashed line*), Slit B (*short-dashed line*), Slit C (*dotted line*). The arrows indicate the observed values for the three slits.

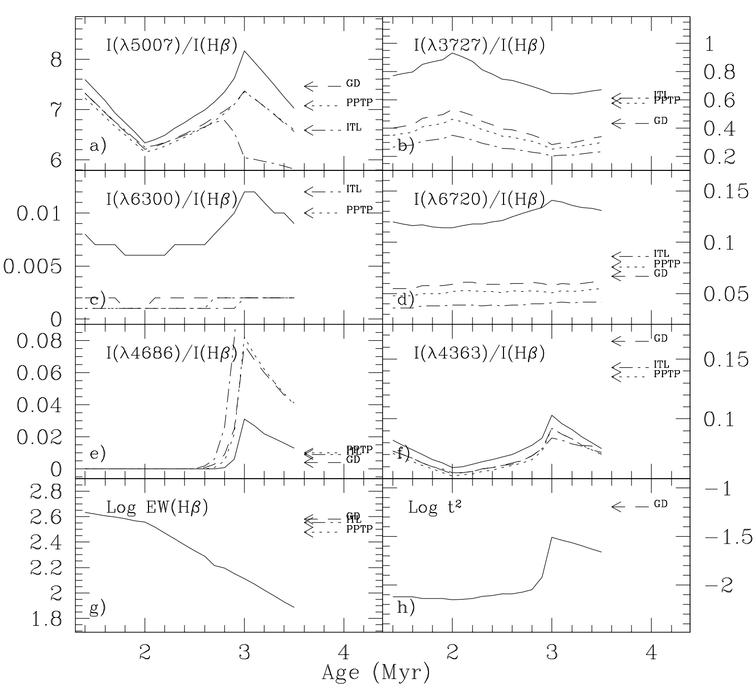

Fig. 2. Intensity ratios (panels *a* to *f*), equivalent width of Hβ (panel *g*) and t^2 (panel *h*) as a function of the burst age, for a sequence of models with $Z_* = 0.25\ Z_\odot$, $Z_{gas} = 0.20\ Z_\odot$. Panels *a-f*: same as Figure 1.

2. RESULTS

In Figure 1 a low-metallicity ($Z_* = 0.10\ Z_\odot$) sequence of models, in which the filling factor is varied while the remaining parameters are kept constant, is shown. These models completely fail to fit the observations: $\lambda\,5007$, $\lambda\,4363$, $\lambda\,3727$, $\lambda\,6720$, and $\lambda\,6300$ are too weak; the predicted $EW(\mathrm{H}\beta)$ is too low; and $\lambda\,4686$ is only marginally reproduced. This result is quite typical of low-metallicity models.

The fit greatly improves when the metallicity is raised to $Z_* = 0.25\ Z_\odot$, in which $I(\lambda\,5007)$, $I(\lambda\,3727)$, $I(\lambda\,6720)$, $I(\lambda\,4686)$, and $EW(\mathrm{H}\beta)$ fit the observational constraints. On the other hand, neither $I(\lambda\,6300)$ nor $I(\lambda\,4363)$ are reproduced, even if $I(\lambda\,6300)$ slightly improves with respect to the low-metallicity case. Figure 2 shows a sequence of typical high-metallicity models, in which the age is varied.

All these facts are consistent with the presence of spatial temperature fluctuations in the nebula, probably due to the interaction between the winds of massive stars and the gas. In such a case, $I(\lambda\,4363)$ has a mechanical contribution which spuriously increases the [O III] temperature, leading to an underestimation of the metallicity. Most lines are not substantially affected by the injection of mechanical energy into the gas, while lines such as $\lambda\,4363$ and $\lambda\,6300$ are. More details on this work can be found in Luridiana, Peimbert, & Leitherer (1999).

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