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PHOTOIONIZATION MODELS OF NGC 346

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We have compared direct estimates of the ionizing photon flux from the stars observed within the H II region NGC 346 in the Small Magellanic Cloud with its observed Hα luminosity using a series of photoionization models of the region. The tests were based on the use of the photoionization code Cloudy (Ferland 2000), aided by H, He, N, O, Ne, S, Ar, and Fe emission line observations of Peimbert, Peimbert, & Ruiz (2000, hereinafter PPR). A key result is that some 46% of the Lyman continuum photons escape from the region. The abundances of N, O, Ne, S, Ar, and Fe relative to H were determined using the ionization structure of the best model, and are compared with those derived from empirical ionization correction factors.

We estimate directly the photoionization spectrum that will be used for the models based on the spectral classification of the blue stars presented by Massey, Parker, & Garmany (1989). We assume that these stars are blackbodies emitting at specified effective temperatures. This assumption is plausible since the stars have high $T_{\rm eff}$. To derive the ionizing flux, we have adopted the stellar parameters presented by Vacca, Garmany, & Shull (1996) and found that the total ionizing flux amounts to $40.06 \times 10^{39}\,{\rm erg\,s^{-1}}$. Using this ionizing luminosity as an input to a homogeneous spherical model for NGC 346 and assuming that all the ionizing photons are absorbed within the nebula, we obtain, using Cloudy a value for the Hα luminosity of the H II region of 1.78×10^{39} erg s^{-1}.

From the observed Hα flux of 1.55×10^{-9} erg s^{-1} cm^{-2} (Kennicutt & Hodge 1986), an interestellar absorption correction of $C({\rm H}\alpha) \sim 0.10$ dex (from PPR) and a distance of 64 kpc (Reid 1999) for SMC, the emitted Hα luminosity is 9.55×10^{38} erg s^{-1}. The difference between the Hα luminosity from the stellar radiation and that observed by Kennicutt & Hodge implies that 46% of the ionizing photons escape from NGC 346.

We have implemented different ionization models using Cloudy to reproduce the emission line observations of PPR. The three spherical models are: a constant density model, a clumpy model with a non-zero filling factor, and a clumpy model with two density zones. Plane-parallel clumpy models with a constant density and with two different density regions have also been implemented. All these models are integrated over a volume defined by observed selected slits from PPR and constrained to reproduce the flux derived from observations.

The spherical models cannot fit all the observed line ratios from PPR. The spherical model with two uniform density zones, $n_1 = 140$ cm^{-3} for the inner zone and $n_2 = 50$ cm^{-3} for the outer, agrees well with the observations, although it seems quite difficult to predict [O II] and [O III] simultaneously. Also, while the $I(\lambda4686)/I({\rm H}\beta)$ ratio in the plane-parallel models is underpredicted, the ratio in the spherical models is overpredicted. In all these models, the predicted $I(\lambda4363)/I(\lambda5007)$ ratio is smaller than the observed ratio, probably implying the presence of an additional energy source not included in the models.

The total abundances derived from the model ionization structure agree well for O, Ne, S, and Ar with those determined from empirical ICF predictions. Alternatively the N abundance derived from the models is a factor of two higher than that derived from an empirical ICF prediction, this problem needs to be studied further. The Fe/O ratio is a factor of three smaller than in the Sun, which probably indicates that most of the iron atoms are embedded in dust grains.

REFERENCES

Ferland, G. J. 2000, RevMexAA(SC), 9, 153
Kennicutt, J. R. & Hodge, P. 1986, ApJ 306, 130
Massey, P., Parker, J. W., & Garmany, C. 1989, AJ 98, 4
Peimbert, M., Peimbert, A., & Ruiz, M. T. 2000, ApJ 541, 688 (PPR)
Reid, N. 1999, ARA&A 37, 191
Vacca, W. D., Garmany, C. D., & Shull, J. M. 1996, ApJ 460, 914

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