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30 Doradus as a Nearby Infrared Guide to Starbursts

M.D. Thornley[1], N.M. Förster Schreiber[1], H.W.W. Spoon, R. Genzel, D. Lutz, D. Kunze

Max-Planck-Institut für extraterr. Physik, D-85748 Garching, Germany

1. Overview

We are exploring the properties of obscured starburst galaxies, using observations of atomic fine structure lines taken with the Short Wavelength Spectrometer aboard ISO. However, it is important to ascertain how well our starburst models can recover the properties of the stellar populations in more distant starbursts. For this purpose, we use observations of a nebular "shell" in the 30 Doradus region, to show that our models reliably predict the presence of the very massive stars observed directly in the 30 Doradus region.

We use the population synthesis code STARS (Kovo, Alexander, & Sternberg 1999) to produce a composite spectral energy distribution (SED) for the starburst from a library of model stellar SEDs. Our model library contains a hybrid grid of non-LTE model atmospheres for stars with $T_{eff} > 25000$ K (Pauldrach et al. 1998), standard Kurucz atmospheres for stars with $T_{eff} < 19000$ K, and interpolated models for intermediate temperatures. The photoionization code CLOUDY (Ferland et al. 1996) is then used to predict the nebular emission created by the stellar population.

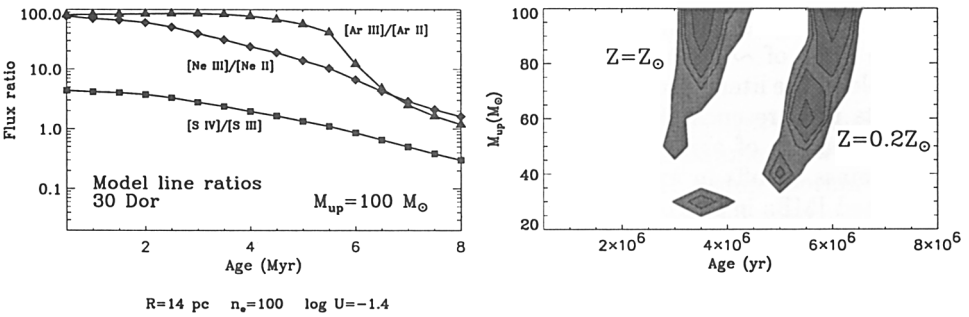

Figure 1. (left) Model line ratios ([Ar III]8.99μm/[Ar II]6.99μm, [Ne III]15.6μm/[Ne II]12.8μm, [S IV]10.5μm/[S III]18.7μm) for the conditions in 30 Doradus. (right)χ^2 fit to the three observed ratios; darker colors indicate a lower χ^2 value. Contours indicate 68.3,90,95.4, and 99% confidence levels, for two metallicities.

[1] *current addresses: MDT, NRAO (mthornle@nrao.edu); NMFS, Saclay.*

The star formation rate is assumed to decay exponentially with a 10^6 yr timescale for 30 Doradus (see Figure 1), and we have compared results for bursts with timescales of 1, 5, and 20×10^6 yr for the starburst galaxies (see Figure 2). We note that the range and variation of predicted ratios with age are dependent on the assumed star formation history.

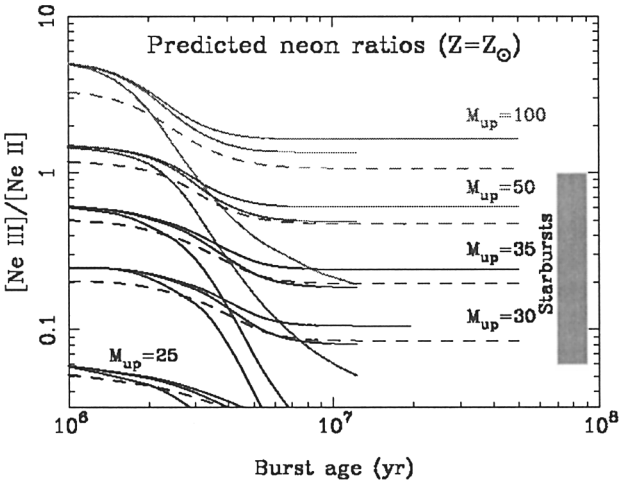

Figure 2. Predicted neon line ratios for starbursts with upper mass cutoffs between 25 and 100 $M_\odot$; for each M_{up}, ratios for timescales of 1, 5, and 20 Myr are shown. Solid lines indicate single cluster models; dashed lines show the effects of including a cluster luminosity function (e.g., McKee & Williams 1997). The range of observed values for over 25 starbursts is shown by the vertical bar at right.

According to our models, the observed nebular line ratios in 30 Doradus require stars of $\sim$100 $M_\odot$ to be present, consistent with stellar classifications available in the literature. Using similar models on a sample of starburst galaxies suggests the presence of stars with masses greater than 25 $M_\odot$ in all sources, and the effects of aging suggest that the observed values are consistent with upper mass cutoffs in excess of 50 $M_\odot$. Thus we find no evidence for strongly truncated IMFs in starbursts.

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