Mass Estimates of Starbursting Galaxies: Line Widths versus Near-IR Luminosities

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Introduction. We present preliminary estimates of the stellar masses of 6 compact, narrow emission-line galaxies (CNELGs) at redshifts $0.10 < z < 0.35$, drawn from earlier studies (Koo *et al.* 1994, 1995, Guzmán *et al.* 1996). In previous work, Guzmán *et al.* (1996, 1998) use galaxy sizes, [O III] λ5007 emission line-widths σ, and the shape of the light profiles to estimate dynamical galaxy masses, M_σ, of the CNELGs. The small line-widths (~50 km/s) and sizes ($R_e \sim 2.5\ h_{50}^{-1}$ kpc) yield virial masses of order $1 - 5 \cdot 10^9\, M_\odot$. However, Guzmán *et al.* point out that the total masses are likely to be up to ~4 times larger: the underlying stellar population may be twice as big as the galaxy half-light radius R_e which was used to estimate the galaxy size, and the [O III] line-widths may underestimate the internal velocities. A key assumption is that the line-widths reflect virialized motion, rather than turbulent motion due to stellar winds. Here, we make estimates of galaxy stellar masses based on K band luminositites, and compare these masses to those derived from emission line-widths and optical sizes.

Analysis and Results. K band images of the CNELGs were obtained with the KPNO Mayall 4-m telescope in 1994. To derive galaxy stellar masses from near-IR luminosities, the simplest case is to assume a constant $(M/L)_K$ for all objects – a useful approximation for normal galaxies, where the K band flux mainly comes from the old stars (Rix 1993). For starbursting galaxies the situation is more complex: both old and young stars contribute substantially to the near-IR flux (Leitherer & Heckman 1995), making it difficult to assign a mass-to-light ratio to the galaxy without detailed knowledge of the burst age and strength (Figure 1, left panel).

Instead, we use population synthesis models ($\sim 0.25 Z_\odot$, and no reddening) to estimate the overall $(M/L)_K$ for a starburst superimposed on an underlying, older stellar population (Schmidt *et al.* 1995, Worthey 1994, Leitherer & Heckman 1995). From $(B-V)$ and $(V-K)$ rest-frame colors we then estimate the ages of starbursts of different strengths; the burst characteristics determine the $(M/L)_K$ ratio of the galaxy. Based on the individual $(M/L)_K$ of each object and its K band luminosity, the stellar masses, M_{NIR}, were estimated. However, the adopted metallicity and reddening values of the burst model, if incorrect, can lead to significant systematic effects: underestimating Z or reddening will lead us to assume older, weaker bursts with higher $(M/L)_K$ ratios, but will weakly affect our estimate of the K band luminosity. In this scenario, M_{NIR} is an upper limit to the true stellar mass. The precise value of $(M/L)_K$ as determined from

Figure 1. **Left panel:** The K band mass-to-light ratio, $(M/L)_K$, is plotted versus the age of the starburst for bursts of varying strengths (100% – pure burst, 0% – older stellar population). **Right panel:** The masses derived from the near-IR luminosities (M_{NIR}) are plotted versus the emission line-width masses (M_σ). Typical error bars are shown. M_{NIR} is typically 4 – 10 times larger than M_σ (shaded area).

broad-band colors can also vary depending on the detailed burst properties and star-formation history.

Nonetheless, the resulting stellar masses are correlated with the line-width masses: on average, the stellar masses are 4 – 10 times larger (Figure 1, right panel). This is roughly the expected result; the line-width method systematically underestimates the dynamical galaxy masses, and the starburst models ignore the effects of dust reddening and may lead us to overestimate the stellar masses. Implicit in this comparison is that dark matter does not dominate the potential on the small physical scales of the starburst region. While both the line-width and the K band methods for deriving galaxy mass are problematic, used in concert they can place useful limit on stellar (M/L) and masses.

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