Star formation sites in the nearby galaxy NGC 6822

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Области на звездообразуване в близката галактика NGC 6822

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In this thesis we undertake a study of the resolved massive star content of sites of recent star formation (SF) in the Local Group (LG) galaxy NGC 6822 with imaging and spectroscopy. We present the first comprehensive spectroscopic survey of the upper part of the HRD of OB associations beyond the Magellanic Clouds, crucial for deriving the physical parameters of the most massive stars and estimating the evolutionary status of the associations. The spectral observations, combined with multi-band *Hubble Space Telescope (HST)* and UBV *Very Large Telescope (VLT)* imaging allow us to fully characterize the massive star populations of the studied regions. In parallel we study the integrated ultraviolet (UV) and optical properties of these sites, and compare them with the physical parameters derived from the HR diagrams as a part of our effort to improve the calibration of the integrated UV flux as a star formation tracer.

The VLT optical spectroscopic survey includes 160 young massive stars (40 O–type, and 120 early B–type) in NGC 6822, selected from HST photometry. We obtained both red spectra, to study the mass loss from the $H\alpha$ profiles, and blue spectra, covering the spectral classification interval, for 80% of the most massive members ($M_V < -4.5$, $(B-V) < -0.1$ corresponding to spectral type earlier than B0V) of the associations OB8, OB13, OB6, OB7, OB9, OB11 and OB15. Fainter members of these associations and field stars are also observed. This survey provides the first spectroscopic observations and spectral classification for the majority of these young stars and enables us to construct physical HR diagrams. The parameters of the O–type stars in the spectroscopic sample are derived with spectral modeling using the code FASTWIND. The spectral type, effective temperature relation derived for the O–type stars is similar to the low (SMC) metallicity calibrations.

We also use high resolution multi-band HST WFPC2 (11 pointings taken with filters $F170W$, $F255W$, $F336W$, $F439W$, and $F555W$) and STIS (1 pointing with FUV- and NUV- MAMA) imaging of selected environments in NGC 6822. We derive the physical parameters of the stars and the extinction by comparing the photometry to grids of model magnitudes. The environments studied include one of the most luminous (in Hα) H II regions in the Local Group (Hubble V, containing OB8), the sparse association OB15, and field stars. The density of hot massive stars in the core of OB8 is higher than in OB15 by a factor of 12. The average extinction varies among the environments studied: from $E_{B-V} = 0.22$ in the outer regions to $E_{B-V} = 0.40$ in OB8.

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We also present UBV VLT imaging, covering 54 arcmin^2 overlapping UBV in the Northern part of NGC 6822, which allows us to determine the interstellar extinction and estimate the luminosity of all spectroscopy targets.

The spectroscopy combined with the HST and VLT photometry is used to construct physical HR diagrams of the studied associations. Their ages are determined by comparison of the HR diagrams with theoretical isochrones. OB8 and OB13 are confirmed to be still forming stars. The two earliest stars in our spectroscopic sample, both of O3I-IIIf* type are found in OB8. The most massive stars found in the SF regions OB8 and OB13 are about 60 and 40 solar mass, respectively. OB6 has O–type stars of spectral type O9 and later, suggesting a more advanced stage of evolution. The massive members of OB7 and OB15 are mainly of B–type. Both associations have a WNE member, WN2 in OB7 and WN3 in OB15. The HR diagrams of all but one (OB6) of the studied association are consistent with coeval stellar populations.

We find a correlation between the population age and the projected density of hot stars ($M_V < -4.5$, $(B-V) < -0.1$, or earlier than B0V). The youngest regions OB8 and OB13 have 4.1×10^{-3} and 2.2×10^{-3} hot stars per pc^{-2}, respectively, on the average about 5 times higher than the density of the oldest associations studied, OB9 and OB11 ($\sim 0.7 \times 10^{-3}$ pc^{-2}). The association OB15, outside the main galaxy body, has similar age as OB7 but it is 5 times sparser, which could be explained with its position outside the main body of the galaxy where the dissipation of the dust and gas from which it was born was not perturbed.

We estimate the number of ionizing photons from the O–type stars in OB8 and OB13 and find it to be in excellent agreement with published $H\alpha$ fluxes, confirming that the $H\alpha$ luminosities from these dense regions are good estimators of current SFR.

Integrated *Galaxy Evolution Explorer (GALEX) FUV* (1539 Å) and NUV (2216 Å) flux measurements combined with integrated BV (VLT) measurements are used to derive ages and extinction of the studied regions by comparison with stellar population synthesis models. The ages from integrated measurements, assuming sub-solar metallicity ($Z = 0.008$), are in agreement with the results from the resolved studies if an extinction curve steeper than the average Milky Way (MW) (with $R_V = 3.1$) is assumed, similar to what is found for star formation sites in the Large Magellanic Cloud.

Key words: galaxies: individual (NGC 6822) – Hertzsprung-Russell diagram – stars: early-type – stars: fundamental parameters – stars: formation – ultraviolet: stars

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