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Comparison of $UBVR$ photometry of giant HII regions in NGC 628 with a detailed grid of evolution models of star clusters

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Abstract. We present our $UBVR$ photometry observations of giant HII regions in NGC 628 in comparison with a detailed grid of evolutionary models of stellar clusters to interpret the observed colours of young stellar populations in terms of IMFs and SFRs parameters and dust content. Observed colours are complicate functions of searched IMF, age, regime of star formation as well as chemical abudances and interstellar reddening. A content of database of observed properties is crucial to get significant results. To exclude age-reddening and age-metallicity degenerations we carried out $UBVR$ photometry of 127 giant HII regions are star formation complexes (SFCs) with independently measured chemical abundancies Z and interstellar reddening in NGC 628 by Belley & Roy (1992).

Keywords. HII regions, galaxies: photometry, methods: numerical

1. Observations and the method

Photometry in $UBVRI$ of giant HII regions (star formation complexes — SFCs) in NGC 628 is presented. Observations were made using the 1.5-m telescope of Mt. Maidanak Observatory (Uzbekistan) with an angle resolution 1 arcsec.

To derive the physical parameters of young star formation complexes (SFCs) we use an efficient technique of a deviation functional, first applicated by Sakhibov & Smirnov (2000, 2001). The deviation functional is a numerical function associated with each taken separately evolutionary model of a stellar cluster a definite value. This definite value is a measure of a deviation of a taken evolutionary model from observed photometric values (colour indicies). The deviation functional was computed for every of 13284 nodes of models grid. A detailed grid of evolution models, originated in the Institute of Astronomy of Russian Academy of Sciences (INASAN). The grid involves instantaneous (5508 IB-models) and extended star formation bursts (7776 EB-models), the whole range of IMF parameters and ages from 1 Myr up to 100 Myrs (Piskunov & Myakutin 1996). For every object its own grid of evolution models is computed according to the chemical composition Z derived from independent observational data. Thereby a well known age-metallicity degeneracy can be excluded. The method searches for the minima $\sum_{m=1}^{4}\left[(O-C)_m^{i,j,k}\right]^2$, where $(O-C)_m^{i,j,k}$ are differences between observed and computed colour indices

calculated for every grid node (i, j, k). So one chouses an evolutionary model of stellar cluster with a spectral energy distribution (SED) close to the SED of a real object.

2. Results and conclusion

The comparison of measured values of colour indicies $U-B$, $B-V$, $V-R$ with the detailed grid of evolutionary models of stellar clusters shows an evident displacement between positions of models and real SFCs on two colour diagrams. Improvement for A_V(Balmer) measured by Belley & Roy (1992) is not sufficient to eliminate this displacement. It is quite possible that measurements of A_V(Balmer) are underestimated because of an effect of calibration of H_α and H_β fluxes (Bruevich, Gusev, Ezhkova, *et al.* 2007). Hence we accepted A_V estimations derived directly from the fitting colours with a help of of the deviation functional. An accuracy of the method is $\sigma_{A_V} \approx 0.12^m$. The numerical simulations of the method show a strong correlation between adjusted (input) values of reddening and determined (output) values of reddening. Simulations show also that the output values of the reddening are not affected by the age-extinction degeneracy

We estimated A_V as a function of galactocentric distance r. SFCs located closer to the metal rich central region have a higher light extinction. This trend is evident inside of corotation radius.

Since it is known about the radial trend of chemical abundances Z in NGC 628 determined by Belley & Roy (1992) we considered our estimations of reddening A_V as a function of Z. We show that more chemically enriched SFCs have a higher reddening. A slope of regression line in case of extended bursts greater than slope in case of instantaneous bursts. A great scatter around regression models reflects not only an accuracy of measured values as well as differences in physical conditions in individual SFCs.

There are no obvious correlation between IB SFCs ages and a distance from the centre of NGC 628. The typical ages of IB SFCs are about 6–8 Myrs. While a mean age of EB SFCs increases from 40 Myrs in the central region to 80 Myrs in the outer part of the galaxy. The gradient of EB SFCs ages can be due to two physical factors. The first is that the gas density decreases with the distance from the galactic centre. SFCs with initially lower densities experience a faster dissipation of gas, and the star formation process ends. Second, the differential rotation is stronger at larger distances from the centre, and, it will be disrupted. The disruption time near the corotational radius is about 20–30 Myrs, and could reach hundreds Myrs closer to the centre, in the zone of rigid-body rotation. On the corotation radius (≈ 7.5 kpc) the ages of IB and EB SFCs are similar.

EB SGCs show also a positive trend on the age–metallicity diagram: more chemically enriched EB SFCs are older than less metallicity EB SFCs.

We found three typical scales of star formation in NGC 628: 70, 180, and 500 pc.

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