Hα photometry of low mass stars in 47 Tucanae: chromospheric activity and exotica

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Abstract. We have used archival Hubble Space Telescope (HST) observations obtained with the Advanced Camera for Surveys (ACS) to study the Hα emission properties of main sequence (MS) stars in the globular cluster 47 Tucanae. An accurate photometric measurement of their Hα equivalent width, allows us to identify objects with large Hα emission. We demonstrate that this method allows us to identify and characterise candidate cataclysmic variables (CVs) with high efficiency, reconciling observations with theoretical predictions on the number of dynamically formed CVs expected in a 47 Tucanae-like globular cluster.

Keywords. Stars: chromospheres, cataclysmic variables, globular clusters: individual (47 Tucanae)

1. Summary

Using a method developed by De Marchi *et al.* (2010) we searched for stars showing Hα excess emission (Fig. 1) in the globular cluster 47 Tucanae. A proper combination of HST observations in the F606W (V), F814W (I) and F658N (Hα) bands, allows us to identify objects with large Hα emission and to perform an accurate photometric measurement of their Hα equivalent width (EW(Hα); Fig. 1), that we attribute to mass accretion rather than enhanced chromospheric activity. The spatial position of some of these stars is coincident with that of known X-ray sources and their location in the colour-magnitude diagram allows us to classify them as active binaries (ABs) or cataclysmic variables (CVs; Fig. 2). We demonstrate that this method allows us to identify and characterise for the first time a large number of candidate CVs in 47Tuc. In particular, we detect at least 12 candidate CVs in the region at r$> 70''$ from the cluster center, lying on the blue side of the cluster MS and showing an Hα excess emission with a measured EW(Hα)> 20Å. Only 2 CVs were previously known from X-ray emission in the same region. Under the assumption that the ratio of Hα and X-ray emitters is constant and of order 6 everywhere, we should expect to detect ~ 90 CVs with Hα emission inside the core radius, a number in full agreement with the theoretical expectations. Therefore, by allowing an efficient detection of candidate CVs, our method is able to reconcile theoretical expectation with observations.
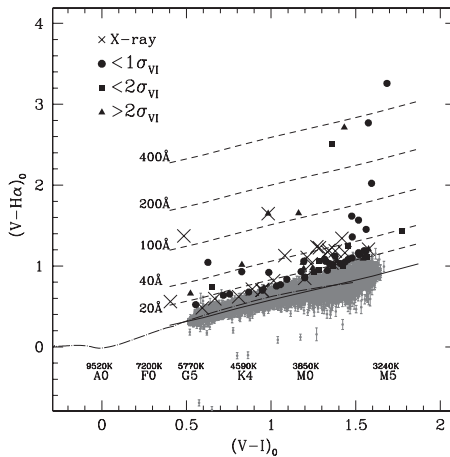
Figure 1. Selection of stars with Hα excess emission in a colour–colour diagram. The solid line represents the median V-Hα colour representative of stars with no Hα excess and hence the location of stars with EW(Hα)=0. Dashed lines show the position of stars at increasing levels of Hα emission. All the objects with Hα excess emission at least 5 times larger than the photometric uncertainty on their V-Hα colours are shown in black. X-ray sources showing Hα excess emission are shown as crosses, while solid circles, squares and triangles indicate Hα excess emitters lying on the CMD at $(V-I)_0$ distance from the MS mean-ridge line, 1, 2 or more than 2 times the combined photometric uncertainty on the colour. The dot-dashed line shows the location of the colour relationship derived for these bands using the Bessel *et al.* (1998) atmospheric models.
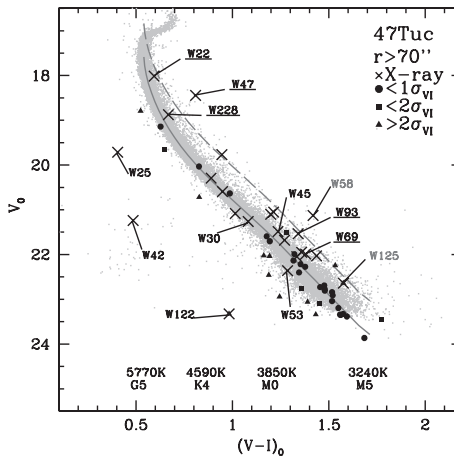

Figure 2. The stars with Hα excess emission and EW(Hα> 20Å) are shown as black symbols in the CMD of the cluster. Crosses mark the optical counterparts to X-ray sources across the whole field of view, whereas the grey data points and the Hα excess sources marked with solid circles, squares and triangles are located outside a 70″ radius. The MS mean ridge line (grey solid line) and the spectral types are also shown. The 6 known CVs (black characters), the 5 ABs (underlined characters) and the 2 LMXBs (grey characters) are explicitly labeled.

References

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