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RR Lyrae Stars of M3 in Optical and Swift/UVOT Near-UV Observations

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Abstract. The Swift/UVOT satellite measured 218 RRL stars of M3 in near-UV (NUV) during the 2011-2013 years overlapping with our ground-based campaign in the optical bands (B, V, I_C) in 2012. The high spatial resolution of UVOT provided the first opportunity to resolve the crowded field of a globular cluster spatially in UV, and enlarged the data coverage in spectral range for a large and homogeneous sample of RRL stars. The previous GALEX and other measurements in this energy range observed scattered field stars, and a few of them were only analyzed in detail. In this short report, we present some of our preliminary results and work yet in progress of a complementary investigation of optical and NUV data focusing on the spectral energy distribution variations considering only unblended, stable RRL stars. In this work, we compare the observed values with static stellar atmosphere model predictions for flux energy distributions to check their consistencies.

1. Introduction

In a ground-based campaign we secured high precision photometric data in the optical bands of RRL stars of M3. In addition, we carried out radial velocity measurements (Jurcsik 2017). These photometric and radial velocity data sets can provide all of the necessary physical parameters for a check of theoretical predictions of atmosphere models for flux energy distribution variations.

Fortunately, the Swift/UVOT measured the RRL stars of M3 nearly parallel with our ground-based effort in the near-UV (NUV). The NUV band refers to the uvw2 filter of UVOT, which has a central wavelength of 225 nm and low optical sensitivity (Siegel 2015). These near-UV observations are the first well covered time series of RRL stars in the crowded field of a globular cluster.

Hence, in principle, combining the optical and NUV databases we can check the theoretical flux calculations and can determine several deduced parameters precisely. Previous analyses of GALEX and other measurements have got to the conclusion that static atmosphere models and flux distribution predictions fit quite well to the observations (Wheatley 2012). In their analysis the estimates of physical parameter variations are based mostly on assumptions. However, in our case of M3, we have well determined and consistent description of the physical parameter variations, which narrow down strongly the possible interpretations of the flux variations. The final goal of our investigation is to check of flux variation fittings predicted by static atmosphere models.

2. Discussion

One of the basic assumption of static stellar atmosphere models is the constant outward energy flux (radiative plus convective), i.e., energy conserving transport supposed without sources. In dynamical atmospheres, this requirement is definitely broken because the moving ionization fronts absorb energy progressing outward and release high energy photons into the radiation field during their regression due to recombination. Hence, from a pure theoretical point of view, we cannot expect a perfect fitting around that time when the shrinking atmosphere is bouncing back. In addition the ionization stored energy, the shock waves emerging at different phases of pulsation also violate this premise, just like the effects of time variable turbulent convection does it.

Dynamical atmosphere models describing all these mentioned features would be required in the case of pulsating stars but that are only available for a few special cases. On the opposite side, the pulsation codes focus on the nonlinear effects and use simplified outer boundary conditions that do not include the physical atmosphere. Our effort is to bring closer the two approaches to give better understanding of the observables.

The Swift/UVOT NUV measurements make it possible to extend the comparison between the observed flux energy distributions and those computed from static model estimates. The measured NUV amplitudes are higher than the optical counterparts as it can be expected. However, the steep increase in the ultraviolet is followed only moderately and by a phase-lag in the optical bands. The temperature variation shows a deficit during shrinking of the star in contrast to the symmetric radius variation and model computations, which gives the indication of additional energy storage mechanisms not considered in the models, and this stored energy is released between the 0.9-1.0 phase range as an excess.

The results of detailed analysis and conclusions with model computations will be published in a forthcoming paper.

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References

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