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Long term near infrared observation of very bright stars at Kagoshima University

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Abstract. We are monitoring nearby long period variable stars (LPVs) in the near infrared K band to establish their precise Period-Luminosity relation. However, they are very bright in the near-infrared and it is difficult to observe them because they are easily saturated on the modern near-infrared camera. We developed a special ND filter, named Local Attenuation Filter (LAF), to observe very bright stars. Using LAF, we can observe not only the very bright targets without saturation but also reference stars in the same image. We can perform the accurate relative photometry for the bright stars. We present this new method to observe bright stars as well as the status of our monitoring of nearby LPVs.

1. Introduction

We, Kagoshima university, are monitoring about 1000 long period variable stars (LPVs) selected from the IRAS 2-colors diagram in the near-infrared K band to reveal the structure of Milky Way using the NIR period luminosity relation (PLR) of LPVs. The PLR of LPVs was found and has been mainly calibrated in the Large Magellanic Clouds (Glass and Evans 1981, Feast 1989), but the calibration in Milky Way is not performed well (Nakagawa *et al.* 2016). The improvement of PLR is still needed for the precise distance determination of galactic LPVs. In order to establish the high precision PLR of LPVs in Milky Way, the excellent distance measurements for the nearby and less foreground extinction stars are necessary. Hence, we are also monitoring the nearby LPVs with the water maser emission whose distances are expected to be determined by VERA (Japanese VLBI network). However, such nearby LPVs are very bright in the NIR wavelength, typically 1-5 mag in the K band. The modern astronomical instruments are too sensitive, and detector is easily saturated. How can we observe it ?

2. The status of our nearby LPV monitoring

We had observed such bright stars with large defocus, but reference stars in the same image were also defocused and not detected. Therefore, we needed to observe photometric standard stars separately. In order to observe very bright near-infrared stars without saturation, we developed a special ND filter in which only small portion works as the ND filter with a transparency of 1/5000 but the other part does not attenuate the flux at all. We named this filter Local Attenuation Filter (hereafter LAF5000). Fig.1 is a picture of LAF5000 in the filter cassette. The detail of LAF5000 is described in Nagayama(2016). Since only the flux through this patch is attenuated and the fluxes passing outside the patch are not attenuated, the attenuated region is generated on the part of detector array if we install LAF5000 near the telescope focal plane. We can therefore observe the attenuated bright star, together with the not attenuated field stars, simultaneously. The field stars can be used as the reference stars for the relative photometry.

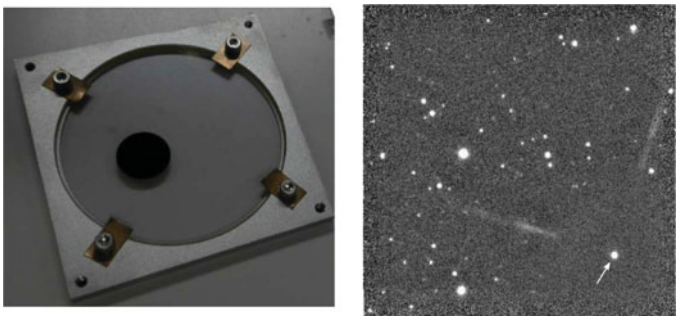

Figure 1. (left) LAF5000 in the filter cassette. (right) An image obtained with LAF5000. The star indicated by the arrow is actually very bright but attenuated by the local attenuated patch in this image.

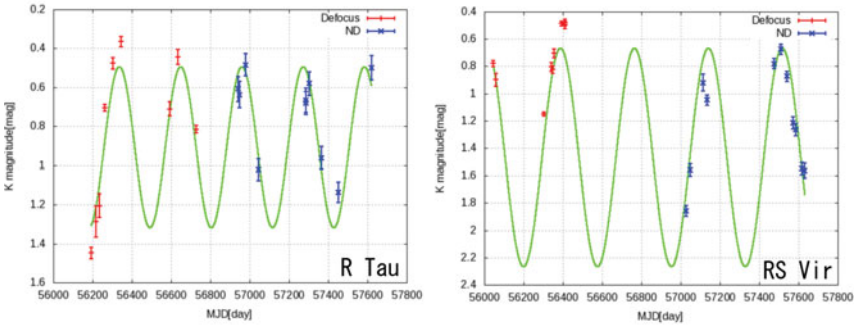

Figure 2. K band light curves of R Tau (left) and RS Vir (right). The data points with MJD<56800 are obtained by the large defocus but >56800 are obtained with LAF5000.

3. Local Attenuation Filter

We are monitoring about 50 bright LPVs for the PLR calibration. Fig. 2 shows the K band light curves of two nearby LPVs, R Tau and RS Vir. These light curves are combination of two observation methods, the large defocus (MJD $<$ 56800) and LAF5000 (MJD $>$ 56800), but we can see that they are connected very smoothly. The number of targets are now limited by the association of bright water maser because the only method to determine the accurate distance of them before Gaia is the VLBI observation for the maser sources. However, we are considering to extend our target to all nearby LPVs. Nearby LPVs are very bright in NIR, but not so bright in the Gaia wavelength. Therefore, they are not saturated in the Gaia photometry and we expect that Gaia determine their distance accurately.

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