Possible variability of interstellar reddening in the line of sight of NGC 4833

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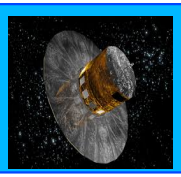
Size of the smallest structure of neutral clouds

Fractal cloud [1]

Hierarchical or fractal structure ?

NGC 4833 [2]

Observations of a globular cluster in a dusty region



Gaia satellite [3]

Will Gaia be able to detect variations of differential reddening ?

What about ? : Pfenniger & Combes [4] proposed that the fractal structure seen in CO at large scales should extend down to AU scales, and should be associated with the outer Milky Way disk, as seen in CO and HI.

- **Our goal is to detect time variations of the observed optical reddening, which has never been identified before and might be explained by the nature of the gas in the foreground.**

How ? : Compare observations carried out by our team of the globular cluster, NGC 4833, on January and July, 2006 (at the NTT), which lies behind dusty regions and thus provide ideal means of looking for small-scale time variations of the extinction.
The tangential velocity of NGC 4833 is $v_T = 251\, km.s^{-1}$, therefore it moves at 26 AU relative to the gas in the foreground. This value is comparable to the typical size of small structures of the interstellar medium considering a fractal structure of the gas.

Why ? : Highlight time variations of the reddening and predict the variable reddening for Gaia photometry.

Methodology and results

We made use of DAOPHOT II [5] crowded field photometry package.

If time variations are due to a Variable Interstellar Reddening (VIR hereafter), one expects that :

$$\begin{aligned} |\Delta(B)| &= (1.4 * |\Delta(V)|) \pm 0.5 \\ |\Delta(I)| &= (0.6 * |\Delta(V)|) \pm 0.5 \end{aligned} \quad (1)$$

In this study we have restricted our targets to dwarfs in a short interval of temperatures : $0.8 \leqslant (B-V) \leqslant 1.1$.
Their membership is also being studied.

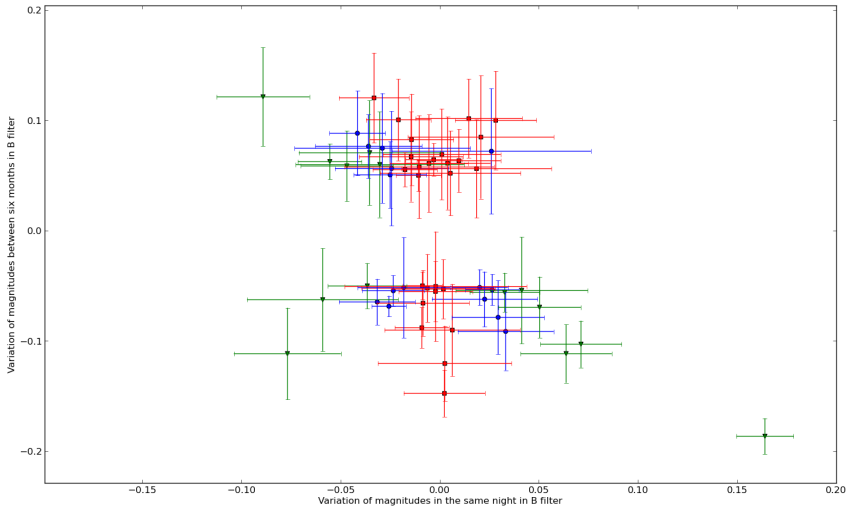


Fig. 1 : (from J. Itam-Pasquet et al, in prep) Photometric variations in B filter of 57 stars which meet the VIR test (equation 1) in NGC 4833 between six months (Y-axis) which are three times (resp. two times) higher than variation in the same night of the same star (X-axis) are represented by red squares (resp. blue circles). The others variations, less significant, are in green triangles.

Confidence of results

1. Probability that a star varies due to a VIR

Making use of Wilcoxon and Kolmogorov-Smirnov tests, we found that the logistic distribution is the best distribution fitting our data. Then, a maximum-likelihood estimation gave us the scale parameters of the distribution.

After the VIR test, the probability that a star has a variation higher than |0.05| mag due to the interstellar extintion is found to be higher than 85%, which is very significative (see Fig. 2).

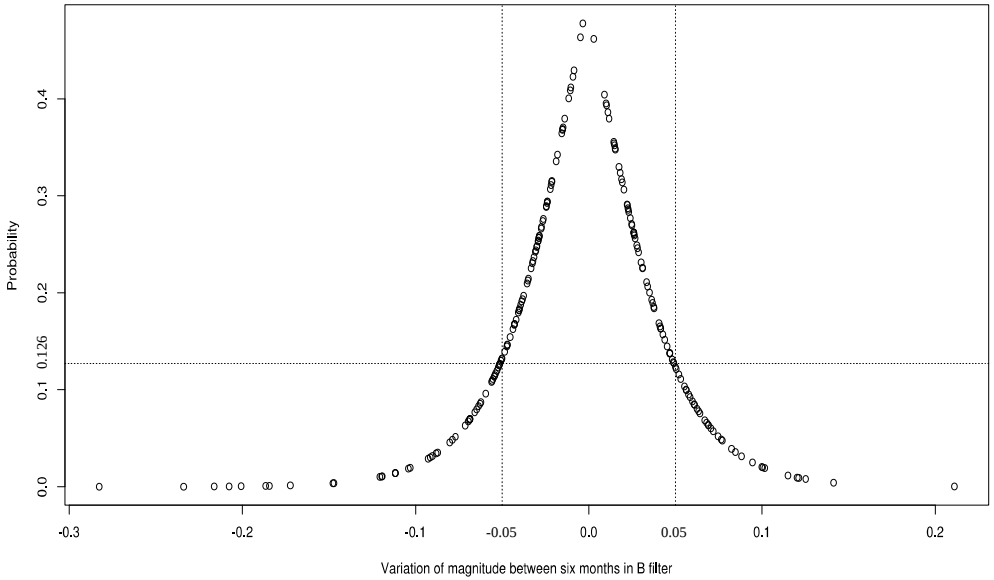


Fig. 2 : (from J. Itam-Pasquet et al, in prep) Probability of occurrence of photometric variations of stars which meet the VIR test in NGC 4833 between six months in B filter.

Confidence of results

2. Discarding binary stars

- Kopacki et al. [6] listed the well known variable stars in NGC 4833 and placed them in a color magnitude diagram, allowing us to check if candidates are not known as intrinsic variable stars (see Fig. 3). The fraction of binary stars is estimated to be 0.058 ± 0.006 in NGC 4833 [7].

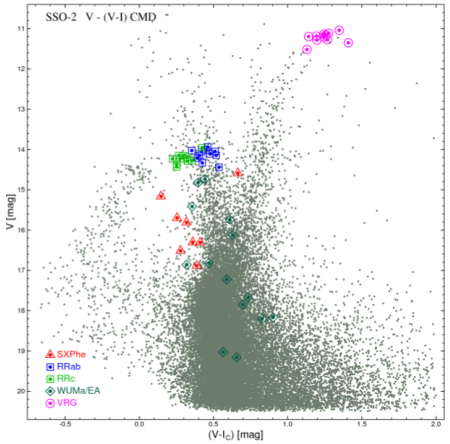


Fig. 3 : [6] Color magnitude diagram of NGC 4833. Each mark represents a kind of variable star.

- To complete this study, we have to evaluate statistically how photometric variability, due to binaries could mimic a VIR. In this way, we checked if BVI magnitudes in the light curve of several intrinsic variable stars (WUMa) satisfy to a VIR. We performed 100 simulations for these variable stars and we found that none mimics a VIR.

Conclusions and outlooks

The study of the globular cluster NGC 4833, is particulary relevant because it lies behind dusty regions. We believed that the interstellar medium in the foreground, is composed of large and small structures of about few AUs. Thanks to these structures and the velocity of NGC 4833, time variations of the reddening may occur. In this way, we highlighted 57 candidates over NGC 4833.
Statistics processing show that, the likelihood of variations higher than |0.05| mag are due to a VIR, is greater than 85 %.

Future work :

- We applied for ESO observations with the NTT to carry out new observations of NGC 4833 (our current data date back to 11 years).
- We will further constrain the structure of the gas in the foreground, as we will obtain 3 mm observations with the 22-m single-dish radio telescope Mopra in Australia, on July and August, 2015. Our goal is to estimate the AU sized structure of the gas in the line of sight of NGC 4833 and link them to the variations of the reddening.
- We are writing a SRS for the Gaia CU7 for Variability Processing to build an algorithm able to detect reddening variations by studying of BP and RP spectra.

References :
[1] Sánchez, N., Alfaro, E. J., & Pérez, E., ApJ, 656, 222, 2007
[2] NGC 4833 by Hubble Space Telescope from NASA website
[3] Gaia satellite image from CNES website
[4] Pfenniger, D. & Combes, F., A&A 285, 94, 1994
[5] Stetson, P. B., PASP, 106, 250, 1994
[6] Kopacki, G., proceeding IAU Symposium, N°301, 2013
[7] Milone, A. P. , A&A, 540, A16, 2012

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