Colour relations for Mira and Semiregular (SR) type stars

Yavuz Guney¹, Cahit Yesilyaprak²,³

¹ Atatürk University, Science Faculty, Department of Physics, Erzurum, Turkey
² Atatürk University, Science Faculty, Department of Astronomy and Astrophysics, Erzurum, Turkey
³ Atatürk University, Research and Application Center of Astrophysics (ATASAM), Erzurum, Turkey

E-mail: yguney@atauni.edu.tr

Abstract. In this study, the period-colour relations, the colour-colour relations and the effective temperature were examined for Semiregular (SR) and Mira type variable stars. SR variables show an obvious period-colour relations, especially in infrared (IR). There are differences between SR and Mira type variable stars with respect to their colour relations. It has been thought that these differences are caused by their mass loss rates and their effective temperatures.

1. Introduction

Semiregular (SR) and Mira variable stars are pulsating stars. In the General Catalog of Variable Stars (GCVS4), SR variable stars are defined as intermediate (F, G, K) or late spectral type (M, C, S) giants or supergiants. Mira variable stars are defined late spectral type. Long period variables (LPV) form an important class of red giant stars. They traditionally comprise Miras, SR and irregular (L) variables according to the amplitude and the regularity of their visual light curves. They are known to be either O-rich or C-rich, and comprise thus M, S and C stars. More recently OH-IR sources have been found from infrared and radio observations showing that they belong to the LPV population with periods up to 2000 days [1,2].

The periods known classically change from 20 to 2000 d or more for SR variables in GCVS4. Many SR variable stars have multiple periods [3,4,5]. The visual (V) light amplitude is, as a rule, less than 2.5 mag in SR variable stars [1]. The visual light amplitude is bigger than 2.5 mag in Mira variable stars.

2. Stars selection and data base

The stars were selected from: Hipparcos and Tycho Catalogue [6], General Catalog of Variable Stars (GCVS4) [1,7] and SIMBAD database [8] for SR and Mira type variable stars. GCVS4 is selected stars which parallax. Hipparcos and Tycho Catalogue is joined by selecting the SR and Mira variable stars. The total number of stars are 1288. Data from different types of selected stars were taken the following catalog. The Guide Star Catalogue (GSC), The AC 2000.2 Catalogue, All-Sky Comiled Catalogue of 2.5 Million Stars, AKARI/HIP and AKARI/2MASS samples, The USNO-A2.0 Catalogue, NOMAD Catalogue, The USNO-B1.0 Catalog, TASS Mark IV Patches Photometric Catalog, The PPMXL Catalog, IRAS Point Source Reject Catalog (IRAS), SKY2000 Catalog, Stellar Photometry in Johnson’s 11 Color System, Orion Spiral Arm Catalogue (OSACA), Hipparcos Red Stars, The FON Astrographic Catalogue (FONAC), Tycho-2 Spectral Type Catalog.

3. Method

Colour values are not the stars of colours, known brightness values of different wavelengths is calculated by taking the difference. Fluxs value in infrared bands, are converted to magnitude, as shown in equations 1 below [9].
\[
[12] = 3.63 - 2.5 \log_{10}(F_{12}) \\
[25] = 2.07 - 2.5 \log_{10}(F_{25}) \\
[60] = 0.19 - 2.5 \log_{10}(F_{60}) \\
[100] = -0.92 - 2.5 \log_{10}(F_{100})
\] (1)

4. Results and Discussions

A two-colour \( (V - I / V - [12]) \) diagram for SR and Mira type variable stars is, as shown in Figure 1.

**Figure 1.** \( V - I \) versus \( V - [12] \) for SR and Mira variable stars. Mira variable stars are shown as open symbols while SR variable stars are closed symbols.

It was determined that Mira diverge more from this linear correlation, while SRs are gathered around a linear correlation. In SR type stars, this reason is either the different modes are pulsating red stars or SRa are the stars. Mira type variable stars has appeared that showed more unknown distributions. However, SR and Mira type stars have been found that it can be easily distinguished from the colour correlation.

Period – colour diagram for SR and Mira type variable stars is, as shown Figure 2.

**Figure 2.** Period- colour relation for SR and Mira variables stars. Mira variable stars are shown as open symbols while SR variable stars are closed symbols.

Period – colour relation has two separate correlations for these two stars. So, Mira and SR stars are dispersed form two separate groups. Mira stars and SR stars with long periods have the same
distribution. The main reason for this, some SR stars have pulsations features such both SR and Mira stars.

Period – colour diagram for SR and Mira type variable stars is, as shown Figure 3.

![Figure 3](image1.png)

**Figure 3.** LogP versus K – [12] for SR and Mira variable stars. Mira variable stars are shown as open symbols while SR variable stars are closed symbols.

It is know that differences in colour between SR and Mira type variable stars. It is found that is show different period-colour and colour-colour relation in short and long period of SR and Mira type variable stars.

The more SR type stars is show sudden increase in K – [12] colour values that have K – [12] > 0.75 colour values, after 60-70 days. It was detected to be mass loss limit in 60-70 days period for SR variable stars [10].

Effective temperature – colour diagram for SR type variable stars is, as shown Figure 4.

![Figure 4](image2.png)

**Figure 4.** V – K versus $T_{\text{eff}}$ for SR variable stars.

The effective temperature of SR stars change about between 2500-4000 K. The effective temperature of SR stars can be expressed by more than one star in the red and infrared colour. The responsive colours to the changes in the atmosphere of these stars are J – K and H – K colours [11].

A linear correlation is found between V – K colour index and effective temperature for SR type variable stars. The deviations on the diagram are thought to be caused by the errors in the measurements of effective temperature or determination of colour index. Because of their
atmospheres, there is no significant linear correlation between V – K colour index and effective temperature for Mira-type variable stars.

A two-colour (V – I / B – V) diagram, was plotted for all SR variables with different spectral types (F, G, K, M, C, N, R and S) in the Hipparcos Catalogue [6]; the result is shown in Figure 5.

![Two-colour diagram](image)

**Figure 5.** Two-colour diagram (V – I / B – V) of all SR variables in the Hipparcos Catalogue according to different spectral types.

Figure 5 shows that M-type SR variable in particular behave distinctly and are well separated from the linear relation formed by other spectral types of SR variables [10]. The distributions of both Mira and L-type variables are similar to that of the of M-type SR variables shown in Figure 5 [12].

**References**

[1] Kholopov P N et al 1988 General catalogue of variable stars (GCVS and GCVS4) *Nauka Publishing House* 1,2,3,4

[2] Mennesier M O et al 2001 Long period variable stars: Galactic populations and infrared luminosity calibrations *A&A* 374 968

[3] Johnson H R and Querci F R 1986 The M type stars *NASA Publication* 502

[4] Mattei J A et al 1998 Classification of red variables *The ESA Symposium* 269

[5] Percy J R et al 2001 Periods of 25 pulsating red giants *IBVS* 5041

[6] ESA 1997 The hipparcos and tycho catalogues. Calestia (CD ROM) *ESA Publications Division*

[7] ADC 1997 Selected astronomical catalogs *NASA Publication* 4

[8] CDS 2002 Centre de Donnees astronomiques de Strasbourg (CDS) *SIMBAD Astronomical Database* http://simbad.u-strasbg.fr/Simbad

[9] Walker H J and Cohen M 1988 The classification of stars from IRAS colours *AJ* 95 1801

[10] Yesilyaprak C and Aslan Z 2004 Period-luminosity relation for M-type semiregular variables from Hipparcos parallaxes *MNRAS* 355 601

[11] Barthes et al 1999 PLC distribution and classification of galactic O-rich LPVs I. Luminosity calibrations *A&AS* 140 55

[12] Yesilyaprak C and Aslan Z 2008 Kinematics of M-type giant semi-regular variables from the Hipparcos catalogue *Publications of the Astronomical Society of Australia* 25 63

**Acknowledgments**

This study is supported by Atatürk University and ATASAM.