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FBS 2213+421: A DUST - ENSHROUDED
LONG - PERIOD AGB MIRA VARIABLE?K.S.GIGOYAN¹, D.RUSSELL²

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A very red optical and IR-colour indices indicate the presence of a dense circumstellar shell around object FBS 2213+421. The estimated total mass-loss rate is typical for dust-enshrouded oxygen-rich Asymptotic Giant Branch (AGB) Long-Period Mira-type variables. K-band monitoring is necessary to determine the pulsation period, the absolute bolometric luminosity and the distance to this object.

Key words: stars: *Mira type-stars*: individual: FBS 2213+421

1. *Introduction.* We turned our attention to the late-type star FBS 2213+421 recently discovered during the process of making more precise the coordinates for all FBS (First Byurakan Spectral Survey) [1,2] detected M-type and C (carbon)-type stars using POSSI and POSSII databases (Digitized Sky Surveys - DSS1 and DSS2, web site is - <http://skyview.gsfc.nasa.gov>). We detected this object on the FBS survey plate (No 932) and estimated it as a star of M5-M6 subclasses, according to the energy distribution in low-resolution spectrum ($\sim 1800\text{\AA}/\text{mm}$ near $H\gamma$, see more details in the paper [3] and the database - <http://www.aras.am> for FBS low-resolution spectral characteristics for various type of objects).

But this object was erroneously not included in the second list of the new discovered FBS late-type stars [4]. The DSS2 database gives the following coordinates: R.A. = $22^{\text{h}}15^{\text{m}}58^{\text{s}}.87$ and DEC. = $+42^{\circ}22'46''.6$ ($l=95^{\circ}$, $b=-12^{\circ}$) for FBS 2213+421 for equinox J2000 (on both DSS2, blue and red charts the star is on the limit of survey and is hardly visible). Fig.1 represents the DSS1 and DSS2 (blue and red) digitized finding charts for FBS 2213+421.

2. *Other identifications.* For other possible identifications in existing catalogues we have used the SIMBAD astronomical database (<http://simbad.u-strasbg.fr>). We found identifications with V381 Lac (or LD 197) in the Combined General Catalogue of Variable Stars [5]. In the last version of this Catalogue this object (LD 197) is presented as a NL-type (Nova-Like)?? star, based on paper of Dahlmarm [6], who has observed 32 fields in the Milky Way for variable stars. Two maximum in V band (with values

$V=12^m.5$) was found for LD 197 [6]. At its minimum the star is fainter than $16^m.2$, i.e. fainter than the detection limit of Dahlmars survey [6].

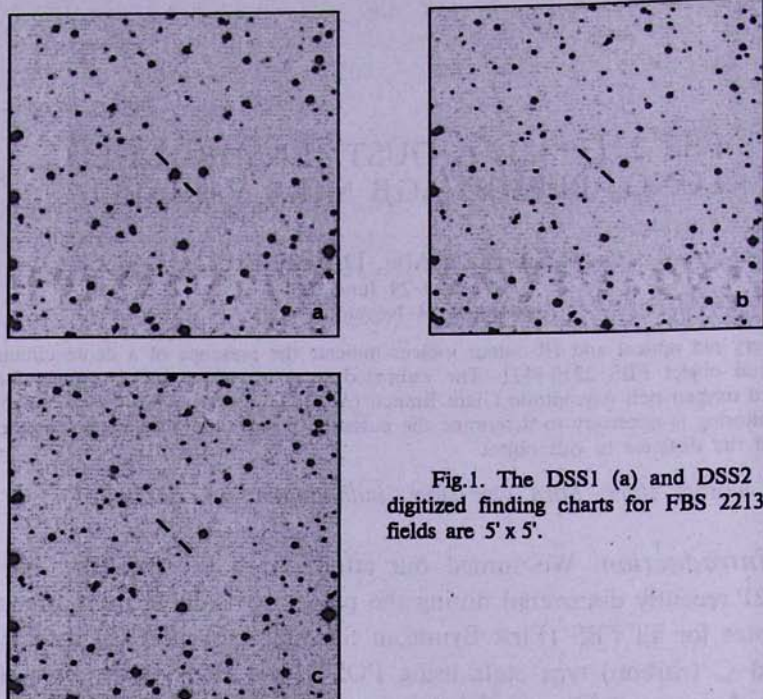


Fig.1. The DSS1 (a) and DSS2 (b and c) digitized finding charts for FBS 2213+421. All fields are $5' \times 5'$.

Other identification is also IRAS PSC 22138+4207 [7], where IRAS Low-Resolution Spectral (LRS) class for this object is noted as 14. Primary, the LRS spectra for PSC 22138+4207 are presented in [8].

3. *Optical and IR-photometric data.* In Table 1 and Table 2 we present the USNO-B1.0 [9] and 2MASS Point Source Catalogue (PSC)

Table 1

THE USNO-B1.0 CATALOGUE DATA FOR FBS 2213+421

Epoch (J2000)	USNO-B1.0 Number	Pm.RA (mas/yr)	PmDEC (mas/yr)	<i>B</i> ₁ mag	<i>R</i> ₁ mag	<i>B</i> ₂ mag	<i>R</i> ₂ mag	<i>I</i> mag
R.A. = $22^h 15^m 58^s.89$ DEC. = $+42^\circ 22' 46''.6$	1323-0557914	0	0	17.63	13.17	20.01	20.03	15.21

Table 2

2MASS PHOTOMETRIC DATA

FBS	2MASS Designation	<i>J</i> mag	<i>H</i> mag	<i>K</i> mag
2213+421	J22155887+4222464	13.207	10.196	7.788

(<http://irsa.ipac.caltech.edu>) photometric data for FBS 2213+421.

As we can see, this object has very red optical and IR-colour indices. Particularly, a very red $J-K$ colour indice ($J-K=5.419$, $J-H=3.011$ and $H-K=2.408$) indicates that it is a cool/or more heavily extincted object.

Concerning in more details the investigation results presented in paper [10], devoted to AGB stars in the South Galactic Cap, paper [11], devoted to nature of the IRAS sources in the Galactic Bulge, and also the series of papers [12-16], devoted to obscured AGB stars in the Small and Large Magellanic Clouds, one notes that all objects with similar photometric characteristics are high-mass-losing Long-Period AGB Mira-type variables only.

4. Possible derived parameters. To estimate some important parameters, we use two colour indices, mainly $J-K$ and $K-[12]$ (where [12] is a IRAS $12\ \mu\text{m}$ magnitude, $[12]=3.63-2.5\log F(12)$, according Walker and Cohen [17]), as a measure of the circumstellar shell thickness [10,18]. The empirical relations between $J-K$ and $K-[12]$ colour indices and mass-loss rate (M_{\odot}/yr) are used, obtained for oxygen-rich AGB Mira-type variables [19,20]. The total (dust+gas) mass-loss rate is in order of $3\div 4\times 10^{-5} M_{\odot}/\text{yr}$ for FBS 2213+421, a typical value for Long-Period M-type Mira variables [12-16].

We estimate also the bolometric magnitude ($m_{bol}=8.36$), by applying a bolometric correction - BC (K) to K -magnitude (see paper [18] for objects with $K-[12]>4.8$). Two values are used (as a minimum and maximum for absolute bolometric magnitudes, $M_{bol}=-5^m.1$, and $M_{bol}=-7^m.0$, for mass-losing AGB oxygen-rich Long-Period Mira variables in LMC and SMC [12-16]) to estimate the distance range to FBS 2213+421. Consequently $R_{min}=5.0$ kpc and $R_{max}=12.0$ kpc can be received as min and max values for the distance.

K -band monitoring is necessary to determine the pulsation period as well as the absolute bolometric magnitude for FBS 2213+421 to estimate the rough distance (using Period-Luminosity relation established in papers [10,21] for oxygen-rich Long-Period variables).

5. IRAS LRS Spectra. The IRAS LRS spectra for PSC 22138+4207 are illustrated in Catalogue of Low Resolution Spectra [8], prepared by Olnon and Raimond and is noted as spectra of class 14 (1n, where $n=4$, see various spectral classes more detailly in [8]).

We extracted (<http://vizir.u-simbad.fr/viz.bin/vizExec/get.sp?III>) the LRS spectra in order to re-examine it for some spectral characteristics. Clearly, we can see a <<Blue>> spectra and $9.8\ \mu\text{m}$ absorption band due to silicate particles, i.e., it can be noted as a 3n class spectra [8].

Fig.2 represents the IRAS LRS spectra for FBS 2213+421.

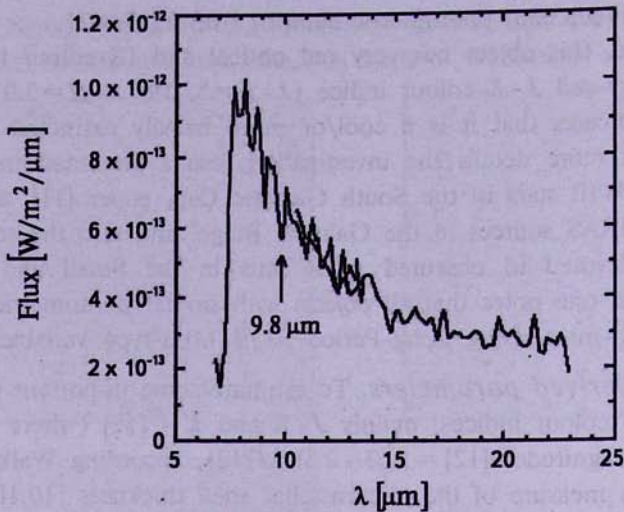


Fig.2. IRAS LRS spectra of FBS 2213+421 in the range 7-23 μm . The 9.8 μm absorption is indicated.

6. *Conclusion.* A very large optical and IR-colour indices in addition to the presence of the 9.8 μm absorption band in LRS spectrum, indicate, that a dense circumstellar envelope is present around this object. Estimation of some parameters shows that the star is a high-mass-losing AGB oxygen-rich Mira variable. *K*-band magnitude is necessary for pulsation period and absolute bolometric luminosity determination, which, using a Period-Luminosity relation, will allow a rough distance estimation for FBS 2213+421.

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FBS 2213+421: ЯВЛЯЕТСЯ ЛИ ПОГРУЖЕННАЯ В ПЫЛЕВУЮ ОБОЛОЧКУ ДОЛГОПЕРИОДИЧЕСКАЯ АВГ МИРИДОЙ?

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Большие оптические и инфракрасные показатели цвета указывают, что вокруг объекта FBS2213+421 существует плотная газо-пылевая оболочка. Полная потеря массы, оцененная для этого объекта, характерна для долгопериодических Мирид на Асимптотической Ветви Гигантов (АВГ). Мониторинг в *K*-полосе необходим для определения периода пульсации, а следовательно и абсолютной болометрической светимости и расстояния этого объекта.

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