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Infrared colours of RS CVn binaries

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Abstract. IRAS 1D COADD data for 82 RS CVn systems have been analysed to obtain their magnitudes at 12 and 25 μm. Their colours V – [12] and [12] – [25] have been computed and discussed. For 62 stars, the excess at 12 μm has been derived using the information on the spectral types of their binary components and measured colours ($B - V$) and ($R - I$). It is found that RS CVn systems have genuine excess at 12 μm. No definite conclusion can be derived for the [12] – [25] excess.

Key words : infrared—binaries—RS CVn stars

1. Introduction

RS CVn systems are known to have small excess infrared emission. The cause for this excess emission is not known. In an earlier work, Verma, Iyengar & Rengarajan (1987) had investigated the infrared excess of 37 RS CVn binaries using the data from the Infrared Astronomical Satellite (IRAS) Point Source Catalog. In this paper we enlarge the scope of that work by using the ADDSCAN data from the IRAS for 82 RS CVn binaries.

The RS CVn sample is taken from Strassmeier *et al.* (1988). Of the 104 RS CVn stars in their list we selected 82 stars with V magnitude < 9. Using the ADDSCAN/SCANPI routine on the 1D Coadded data for these stars, we derived their flux densities at the 12 and 25 μm. The scan profiles for this were obtained using the median coaddition of the data strings. Sixty-three stars have definite flux density at 12 μm (with $S/N > 3$ and correlation coefficient > 0.95); 41 stars had definite flux densities at 25 μm (with $S/N > 3$ and correlation coefficient > 0.90). These flux densities have been colour corrected as per the IRAS prescription, converted into magnitudes and the observed colours V – [12] and [12] – [25] computed. These are given in table 1.

2. V – [12] colour

The expected value of V – [12] has been determined in several ways by using the colour relations given by Waters *et al.* (1987). These methods (in decreasing order of accuracy) are :

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Table 1. Infrared colours of RS CVn binaries

No.	Name		V	[12]	[25]	[12] – [25]	V – [12] Obs.	V – [12] Pred.	Excess [12]
1	33	Psc	4.61	2.09 ± .006	2.07 ± .053	0.02	2.52	2.48^d	0.04
2	BD	Cet	8.20	4.96 ± .085	—	—	3.24	2.66^e	0.58
3	13	Cet	5.20	3.83 ± .033	3.71 ± .158	0.12	1.37	1.47^e	–0.10
4	ζ	And	4.06	1.39 ± .005	1.30 ± .016	0.08	2.67	2.69^d	–0.02
5	CF	Tuc	7.47	5.29 ± .112	4.94 ± .206	0.35	2.18	1.83^e	0.35
6	AR	Psc	7.28	4.67 ± .071	—	—	2.61	2.10^e	0.51
7	TZ	Tri	4.94	2.66 ± .008	2.60 ± .030	0.06	2.28	1.92^e	0.36
8	VY	Ari	6.90	4.17 ± .041	3.90 ± .109	0.27	2.73	2.29^e	0.44
9	LX	Per	8.20	6.32 ± .290	—	—	1.88	1.86^e	0.02
10	UX	Ari	6.50	3.58 ± .020	3.67 ± .163	–0.09	2.92	2.18^e	0.74
11	V711	Tau	5.70	3.01 ± .010	2.90 ± .050	0.11	2.69	2.20^e	0.49
12	HD	22403	8.10	5.40 ± .089	—	—	2.70	1.76^e	0.94
13	EI	Eri	6.95	5.22 ± .069	—	—	1.73	1.83^d	–0.10
14	RZ	Eri	7.70	5.57 ± .086	—	—	2.13	1.41^b	0.72
15	12	Cam	6.10	3.33 ± .024	3.28 ± .118	0.05	2.77	2.63^e	0.14
16	α	Aur	0.08	−1.89 ± .001	−1.97 ± .001	0.08	1.97	1.94^a	0.03
17	TW	Lep	7.00	4.44 ± .043	—	—	2.56	2.16^e	0.40
18	HD	37824	6.67	3.85 ± .027	3.90 ± .113	–0.05	2.82	2.68^e	0.14
19	SZ	Pic	7.90	5.82 ± .097	—	—	2.08	1.98^e	0.10
20	HD	46697	7.61	4.91 ± .030	4.65 ± .100	0.26	2.70	2.70^e	0.00
21	AR	Mon	8.62	5.88 ± .127	—	—	2.74	2.54^e	0.20
22	σ	Gem	4.14	1.44 ± .006	1.42 ± .021	0.01	2.70	2.65^d	0.05
23	TY	Pyx	6.87	5.04 ± .056	—	—	1.83	1.85^a	–0.02
24	IL	Hya	7.40	4.81 ± .059	—	—	2.59	2.52^d	0.07
25	HD	83442	9.00	5.82 ± .131	—	—	3.18	2.75^e	0.43
26	ξ	Uma(B)	4.87	2.13 ± .005	2.13 ± .024	0.00	2.74	2.38^e	0.36
27	HD	101309	7.95	5.13 ± .100	4.94 ± .347	0.19	2.82	2.24^e	0.58
28	HR	4492	5.17	2.15 ± .010	2.08 ± .017	0.07	3.02	2.46^c	0.56
29	93	Leo	4.50	2.72 ± .010	2.65 ± .049	0.07	1.78	1.70^d	0.08
30	DK	Dra	6.14	3.37 ± .011	3.28 ± .059	0.10	2.77	2.63^e	0.14
31	HD	113816	8.27	5.13 ± .163	—	—	3.14	2.70^e	0.44
32	RS	CVn	7.93	6.08 ± .174	—	—	1.85	1.85^a	0.00
33	HD	116204	7.21	4.23 ± .038	4.43 ± .156	–0.19	2.98	2.73^e	0.25
34	HR	5110	4.95	3.37 ± .014	3.23 ± .075	0.14	1.58	1.08^e	0.50
35	HD	136901	7.21	4.12 ± .025	4.03 ± .099	0.09	3.09	2.93^e	0.16
36	GX	Lib	7.31	4.73 ± .077	4.13 ± .357	0.60	2.58	2.52^d	0.06
37	HD	137164	7.00	4.63 ± .055	—	—	2.37	2.46^e	–0.09
38	σ^2	CrB	5.70	3.62 ± .017	3.51 ± .050	0.11	2.08	1.60^e	0.48
39	WW	Dra	8.22	6.01 ± .075	—	—	2.21	1.99^a	0.22
40	ε	UMi	4.23	2.03 ± .003	1.99 ± .010	0.04	2.20	2.18^d	0.02

(continued)

Table 1. (Continued)

No.	Name		V	[12]	[25]	[12] – [25]	V – [12] Obs.	V – [12] Pred.	Excess [12]
41	V792	Her	8.50	5.44 ± .089	—	—	3.06	2.47^b	0.59
42	V824	Ara	6.72	4.45 ± .044	4.30 ± .109	0.16	2.27	2.03^e	0.24
43	HR	6469	5.51	3.72 ± .012	3.71 ± .067	0.02	1.79	1.72^e	0.07
44	29	Dra	6.55	3.89 ± .012	3.90 ± .050	–0.01	2.66	2.48^e	0.18
45	Z	Her	7.30	5.82 ± .126	—	—	1.48	1.54^e	–0.06
46	V772	Her	7.07	5.13 ± .057	—	—	1.94	—	—
47	V815	Her	7.66	5.71 ± .119	5.18 ± .285	0.53	1.95	1.80^e	0.15
48	o	Dra	4.67	1.67 ± .002	1.59 ± .006	0.07	3.00	2.99^d	0.01
49	HR	7275	5.81	3.11 ± .009	3.23 ± .052	–0.12	2.70	2.57^e	0.13
50	HD	181809	6.76	3.98 ± .030	3.71 ± .105	0.27	2.78	2.48^d	0.30
51	HR	7428	6.32	3.33 ± .010	3.12 ± .025	0.20	2.99	2.73^e	0.26
52	HD	195040	8.98	5.71 ± .093	—	—	3.27	2.91^d	0.36
53	ER	Vul	7.27	5.71 ± .140	4.94 ± .293	0.78	1.56	1.72^e	–0.16
54	HD	205249	8.00	5.13 ± .084	4.65 ± .301	0.48	2.87	2.16^e	0.71
55	42	Cap	5.18	3.54 ± .015	3.26 ± .106	0.29	1.64	1.66^e	–0.02
56	HK	Lac	6.52	4.04 ± .017	3.94 ± .096	0.10	2.48	2.54^e	–0.06
57	AR	Lac	6.09	4.23 ± .038	4.36 ± .115	–0.13	1.86	1.80^e	0.06
58	V350	Lac	6.38	3.49 ± .015	3.40 ± .056	0.08	2.89	2.75^e	0.14
59	IM	Peg	5.60	2.92 ± .017	2.89 ± .067	0.03	2.68	2.63^e	0.05
60	SZ	Psc	7.20	4.84 ± .062	—	—	2.36	2.04^e	0.32
61	λ	And	3.70	1.21 ± .004	1.17 ± .009	0.04	2.49	2.61^d	–0.12
62	HD	222317	7.04	5.10 ± .088	—	—	1.94	1.70^e	0.24
63	II	Peg	7.20	4.23 ± .053	3.82 ± .116	0.42	2.97	2.39^e	0.58

Note : Superscript on the predicted value of V – [12] indicates the method used to derive the value. The code is same as in the text.

(a) When individual (B – V) and V magnitudes are available, we use the measured values of (B – V) and the V – [12] versus (B – V) relation for each of the two components of the binary, then computing the composite V – [12]. However this method could only be applied to four binaries.

(b) When individual (B – V) are available but not their V magnitudes, then the relative V magnitudes of the two components are computed on the basis of their spectral types and luminosity class (using the tables, Lang 1991) and then V – [12] computed as in (a).

(c) When both spectral types are available but not the individual magnitude and (B – V), the relative magnitudes and (B – V) are estimated on the basis of their spectral types and then V – [12] computed as in (a).

(d) When individual spectral types are not known, by using the measured values of the composite (R – I) and the V – [12] versus (R – I) relation.

(e) When individual spectral types are not known, by using the measured values of the composite (B – V) and the V – [12] versus (B – V) relation.

By comparing the observed value of V – [12] with the predicted V – [12], the infrared excess at 12 μm was computed. The V – [12] versus (B – V) relation reproduces mean

$V - [12]$ within 0.03 to 0.05 mag. (Waters *et al.* 1987). The computations based on composite $(B - V)$ colours (method (e)) can lead to a $V - [12]$ excess, depending on the combination of the spectral types of the two components. This excess becomes significant if the cool component is a giant and the hot component a dwarf; the excess increases with the temperature difference between the two components. The excess magnitude is 0.03 for the combination of K0III/G0V, 0.14 for the combination of K0III/F0V and increases to 0.31 for K0III/A5V. However, it may be mentioned that out of 30 systems for which spectral type and luminosity class of each component is known, only 4 consist of giant/dwarf combination. The predictions based on $(R - I)$ do not have any such bias. Therefore this bias is not likely to have significant effect on the calculated 12 μm excess. We have tried to make the estimate of the excess by using the most suitable method; whenever two estimates of similar accuracy were available, we have taken the smaller excess. This excess is given in table 1. There are 23 stars with excess ≥ 0.3 and no star with a similar deficit. There are 7 stars with excess ≥ 0.5. These numbers can be compared with the 1-2% stars with 12 μm excess in a general sample of G and K stars from Bright Star Catalog and Gliese Catalog as found by Iyengar & Rengarajan (1991). Thus there is a genuine excess at 12 μm among the RS CVn systems as compared to a general sample of stars. The distribution of this excess is shown in figure 1.

3. [12] – [25] colour

The colour [12] – [25] is very insensitive to the spectral type. The average value of [12] – [25] for all RS CVn stars is 0.15 ± 0.03. There are 10 stars with [12] – [25] > 0.2 and none with [12] – [25] < –0.2. However, the error on [12] – [25] (specially for stars showing 25

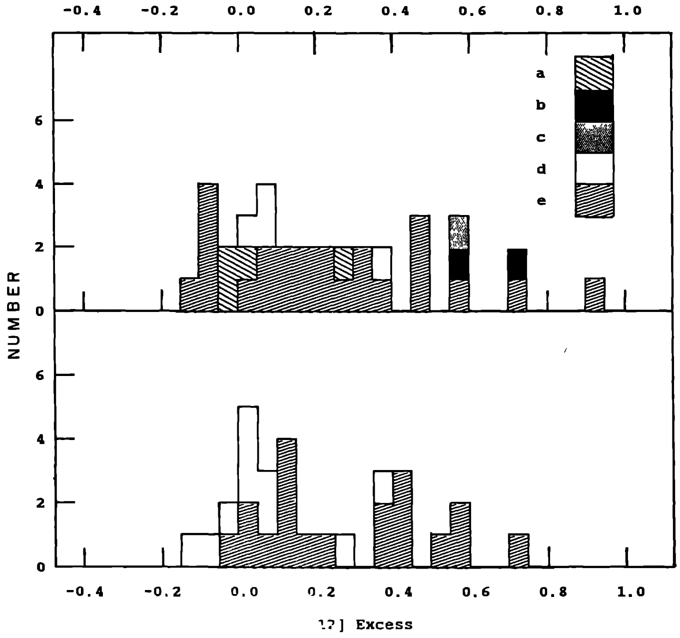

Figure 1. The distribution of the 12 μm excess in RS CVn binaries. Top part of the figure shows the excess for those binaries where spectral types of both the components are known, bottom part shows the same for those binaries for which the spectral type of only one component is known. Different shades show the method by which the predicted value of $V - [12]$ has been obtained. The key to the code is given in the top right corner, with the meaning of a, b, c, d and e same as in the text.

μm excess) is rather large. After excluding stars with the error on [12] – [25] colour > 0.2, the average value is 0.06 ± 0.02. From the distribution of [12] – [25] for stars in the Bright Star Catalog, we find the mean values of [12] – [25] for different types of stars as follows : F stars 0.12; G stars 0.06; K0III-K2III stars 0.04 and K3III-K5III stars 0.05. As most of the RS CVn systems comprise of G/K stars, there is a small 25 μm excess for RS CVn stars compared to the general sample. We have looked at the distribution of [12] – [25] colour for RS CVn systems and compared it with the distribution for G/K starts in Bright Star Catalogue. However, because of the small number and large errors, no significant conclusion can be derived.

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