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F, G AND K TYPE DWARF AND SUBGIANT, CLOSE BINARIES WITH H AND K EMISSION

A feature, and almost a fetish, of variable star astronomy is the creation of special- and to the initiated, esoteric - nomenclature. A recent example is the "RS CVn" (e.g. Hall 1972) class of variables which, originally contained eclipsing binaries with H and K emission lines but has grown to include nearly all close binaries, eclipsing or not. The difficulty with this situation is that it tends, for the wrong reasons, to focus attention on objects that become categorized as "RS CVn" stars and leave in the shadows stars that are physically related but do no happen to obey the current classification rules. The forerunner of the present classification is a series of lists, by Struve (1946), Hiltner (1947), Gratton (1950) and Popper (1976), of close binaries with H and K emission lines - a much clearer, albeit longer, label. I have collected photometric and astrometric data for many of these objects over the last 15 years and this is summarized in Tables 1 and 2, including much referenced data by others. The basic source of H and K emission stars is Bidelman (1954), and the "OCW" reference in Table 2 is to Wilson (1976). All other references to H and K emission presence or widths are given in the discussion below. Some of the little studied systems of most immediate interest may be HD 27130, 81410, 86590, 155555 and 166181 as well as BD +25°2511.

Sparsely represented, but possibly of fundamental importance in understanding the chromospheric activity in these stars, are the contact systems which combine many of the features of "RS CVn" stars and another, allied special classification of "BY And" stars. The H and K emission and the vagaries of the light curves, features of the "RS CVn" objects, are possibly more transient in the contact systems (Eggen 1958, Kuhi 1964, Huruhata 1952, Bergeat et al. 1972). One of the reasons for creating the "RS CVn" class, which includes an arbitrary period cut-off at two weeks, may have been an opinion that the light curve variations are caused by mass exchange, but the continuity of these variations to much longer periods and to obviously detached systems makes such exchange, at most, only one contributing factor. A similar, and perhaps connected, situation obtains for another special classification, the "Flare" stars. These M type dwarfs are generally believed to show violet chromospheric activity because of their youth. However there are some, obviously old M dwarfs that show the same activity. An outstanding example is Wolf 630AB, a visual binary which shares the space motion of a third, distant and much fainter companion (W629) which does not flare. The binary Wolf 630AB has a period of 1.7 years and the components are separated by 1.3 AU (e.g. Eggen 1965) and the implication is that even at this distance, the appearance of youth (i.e. flaring) is induced by the proximity of the stars to one another.

The space motions in Table 2 indicate that most of the objects discussed here are members of the old disk population (i.e. of Hyades age or older) and several appear to be members of such old disk population groups as the Wolf 630 Group and the 61 Cygni Group. The listed proper motions are based on all available data and are on the FK4 system with precessional corrections. There have been suggestions that some of these objects may be T Tauri stars, still in a pre-main sequence stage of evolution (e.g. Hall 1972) but this would appear to be inconsistent with the space motions. However, in this connection it is of interest to consider FK Ser (K5 V) which Herbig (1973) relates to a nearby early type star (HD 170740) and classifies as a post-T Tauri star. The GCVS classifies it as "BY And?" with a period of 5.20 days and a light amplitude of 0.6 mag. The star is a visual binary ($1''.3$) with the companion normally about one magnitude fainter. Herbig also noted hydrogen emission and a strong λ6706 (Li) absorption line in both components of the visual binary. The radial velocity and proper motion listed by Herbig, together with his derived luminosity of $M_V = +3.6$ mag, lead to (U, V, W) = (-1, -38, +9) km/sec, a space motion very similar to that for Wolf 630 which is as old as the cluster M 67. The situation is reminiscent of HD 224085, the last star in Table 1, which has an even higher space motion, based on a trigonometric parallax, and also shows hydrogen emission and λ6706 (Li) absorption.

INDIVIDUAL SYSTEMS

HD 28. The spectroscopic orbit is by Harper (1926). Numerous (UBV) observations indicate a range of about 0.05 mag in V. The intermediate band indices (e.g. Eggen 1977b) are (b-y, M_1, c_1) = (0.625, 0.430, 0.450) mag, which, with (R-I), confirm the subgiant nature and give [Fe/H] near -0.5. However, as noted below, an infrared excess is a feature of several of these systems and R-I may be contaminated by this effect. All indices of this star are closely matched by those of some subgiants in the Wolf 630 Group; for example HD 27588A with (B-V, U-B, R-I, b-y, M_1, C_1, M_V) = (+1.08, +0.94, +0.38, 0.645, 0.440, 0.485, +1.3) mag (Eggen 1978).

HD 4502. A sinusoidal light variation with a visual range of 0.1 mag in the spectroscopic period was found by Stebbins (1928). The amplitude may not be constant. A discussion of the spectrum is given by Gratton (1950). This may be the most luminous object discussed here. Wilson (1976) found H and K emission lines too rotationally broadened to be of use in a luminosity estimate but the star is probably not as luminous as indicated by the spectroscopic luminosity class.

HD 5303. The variation in light (0.3 mag) was found by Strohmeier, Knigge and Ott (1965: BV 625). The spectra are discussed by Hearnshaw and Oliver (1977) and the spectral type is from Houk and Cowley (1975). The H and K lines, from the G star and hydrogen lines from the F star give equal velocity amplitudes. The stars are assumed to be of equal luminosity in Table 2 and, if the radial velocity is near 0 as indicated by Hearnshaw and Oliver, the system is probably a member of the 61 Cygni Group.

HD 13530. The long, spectroscopic period is doubtful. A possible member of the 61 Cygni Group with (U, V, W) = (+87, -54, -17) km/sec, which would give a luminosity more in line with the spectroscopic luminosity class; a high weight Allegheny parallax is 0.010 (wt.20) arcsec. As a result, this object may not belong here either on duplicity or luminosity grounds.

HD 19845. The luminosity from H and K widths is by Fitzgerald (1974) who also finds the components to be of near equal luminosity and mass (1.2 $\odot$), although the secondary eclipse is relatively shallow (Popper and Dumont 1977). Popper (1976) derives radii of 1.6: and 2.8: $\odot$ for the primary and secondary (eclipsed at secondary) stars. Surpisingly, the adopted luminosity leads to a space motion identical to that of the Hyades cluster. In the Hyades, stars with the observed colors of HD 19845, corrected for a reddening of 0.05 mag, will have $M_V = +5.3$ mag. The possibility that the system is a member of the Hyades Group, and therefore some 5×10^8 years old, will be discussed below in connection with Z Her (HD 163930).

HD 21242. Young (1939) found H and K emission and double lines with a velocity separation of 120 km/sec from 8 plates. Carlos and Popper (1971) confirmed these results and found a period of 6.4 days with two components of near equal mass; they assigned a spectral type of G0 V to the primary. Harlan (1969) has previously classified the spectra of the system as G8 IV. The light variation, which is only about 0.05 to 0.1 mag, is phased with the orbital period but shows large variation in amplitude and form (see GCVS and supplements). The magnitude and color in Table 1 are based on a single observation in 1963 and indicate a large ultraviolet excess.

HD 22468A. This is ADS 2644A. The variable radial velocity was found at Mount Wilson and a plate obtained in 1921 showed double lines with a velocity difference of 120 km/sec. Photometry of both components of the wide pair (7") in 1963 lead to the suggestion that the A component may consist of a pair of very old subgiants (Eggen 1966). The (R, I) photometry in Table 1 is based on two identical observations, with the 100-inch reflector in 1963 and the 40-inch Mount Stromlo reflector in 1977. The 13 spectral plates in 1976/6 by Bopp and Fekel (1976) lead to the same velocity difference between the components that was noted at Mount Wilson in 1921, and gave a period of 2.873 days. The variation in the light of the combined components of ADS 2644 was first noted by Cousins (1962). The light variation is very similar to that of UX Ari, with a variable amplitude (0.1 mag) and form of light curve. Photometry of the fainter component of the wide pair gives (V, B-V, U-B) = (8.83, +0.99, +0.79) mag and Wilson (1964) finds the spectral type to be K3 V. Five Mount Wilson spectra of the B component give a mean radial velocity of -14 km/sec (see Abt 1969), which is nearly identical with the systemic velocity of A. Fitting the B component to the main sequence gives a modulus of 2.05 mag, or $M_V = +4.6$ mag for the near equal components of A (Eggen 1966). This luminosity places the components of A some 2 magnitudes above the main sequence at the observed color (B-V = +0.92). The value of R-I of A corresponds to a B-V some 0.1 mag redder than the observed color, indicating an IR excess. There is little doubt that the A and B components of ADS 2644 constitute a physical system. One hundred and thirty years of visual observations have shown an increase in position angle from 235° in

1841 to 264° and a separation from 6.2 arcsec to 6.6 arcsec. These results indicate only that the companion is now near apastron in a very long period orbit.

The luminosity of the components of A is one of the best established values for the stars discussed here and requires comment. The only available evolutionary computations that would place an old disk star in the otherwise unoccupied region between dwarfs and giants near K0 are those for binaries involving interacting components (e.g. Redsfel and Weigert 1969). The end product involves a white dwarf, red dwarf system similar to V 471 Tau in the Hyades cluster. The evolutionary model for this later system (Hills and Dale 1974), which has an initial period near 3 days, would represent ADS 2644A at an intermediate stage of its development. A very similar system, involving a hot subdwarf that is only slightly less evolved that the white dwarf in V471 Tau, is RU Peg (Eggen 1967). The photometry and luminosities of these three systems are listed in Table 3; VB 5 is a Hyades cluster member chosen for its similarity to ADS 2644B.

HD 23838. Young (1939) found a range of 40 km/sec, a mean velocity of 11.7 km/sec, and a spectral type of G0 from 12 plates. Four Mount Wilson plates give a range of 24 km/sec (see Abt 1969) and a mean velocity of 26.1 km/sec. A weighted mean has been adopted in Table 1. From an unpublished catalogue by Strömgren, Perry and Crawford the value of (b-y) = 0.485 mag. No value of R-I has been published but the red colors by Hall (1938) for G stars transform well to R-I, giving the value listed in Table 1. The (R-I, b-y) relation (Eggen 1977b) show the star to be a dwarf unless, like several objects discussed above, there is an (R-I) excess. Spectroscopic and photometric observations are needed.

+16°516. This red dwarf, white dwarf system (see Young and Nelson 1972) is discussed in connection with HD 22468 above. The UBV observations were obtained during the eclipse of the white dwarf (Young and Nelson 1972); the value of R-I is based on two observations with the Siding Spring Observatory 1 m reflector (R = 9.20 mag). The system is an outlying member of the Hyades cluster.

HD 27130. Sanford (1924) has derived a period of 5.6 days for the single lined spectrum. However, Wilson (1963) noted strong and double H and K emission lines on several plates. The similarity with LX Per would indicate that a more extensive study is important.

HD 27149. A member of the Hyades cluster. The double lines were found in the spectra by Woolley, Jones and Mather (1960) and the spectroscopic elements derived by

Battan and Wallerstein (1973), who also found a magnitude difference of 0.4 mag between the components and a mass ratio near 1. Although Batten and Wallerstein measured the H and K emission for velocity determinations they make no comment on the emission strength. Jorgensen and Olsen (1972) found no variation in light.

HD 30050. The spectroscopic elements are by Cesco and Sahade (1945) who also quote W.W. Morgan's classification of the primary component as a metallic line star. Morgan classified the secondary as a G8 subgiant with M_V near +3 mag. Grønbech (1975) has derived Strömgren indices for the two components; $(V, b\text{-}y, m_1, c_1) = (8.26, 0.285, 0.200, 0.867)$ mag and (8.71, 0.717, 0.340) mag for the primary and secondary, respectively. The primary has a value of (b-y) that is larger than for known Am stars (Eggen 1976) and the value of $\Delta[c_1]$ places it 3 mag above the main sequence at $M_V = +0.6$ mag. The secondary would then be a giant with $M_V = +1.1$ mag. This is brighter than the other stars discussed here but inherent uncertainties in the derivation of the luminosity, and the probable peculiarities of the spectrum, and therefore the color indices, leave the possibility that the faint component is nearer +3 or +4 mag.

HD 44982. The spectroscopic study is by Hiltner (1953) and a summary of observations of the light variation is given by van Woerden (1957). The light curve shows continual variation in form and amplitude. The available data indicate stars of near equal (solar) mass with the secondary star possibly slightly the more massive, as is the case in many of the systems discussed here.

HD 65626. This star is a double lined spectroscopic binary with the components of near equal mass and differing by only 0.4 mag (Harper 1939). The H and K emission was noted by Young and Koniges (1977) who find $M_V = +3.5$ mag. The listed photometry is based on two observations with the Palomar 20-inch reflector in 1966; the two observations were separated by 70 days and give identical values for the magnitude.

HD 77137. The radial velocity results are by Andersen and Popper (1975). The components are approximately equal in mass and luminosity. Variations in magnitude of 0.05 to 0.1 mag over a few hours were noted in the photometry. Two observations at maximum light give $(b-y, M_1, C_1)$ = (0.435, 0.210, 0.455) and the stars are very similar to HD 131923 (G5 V) in the Wolf 630 Group (Eggen 1978) with $(B-V, U-B, b-y, M_1, C_1, M_V)$ = (+0.71, +0.24, 0.455, 0.195, 0.460, +5.1) mag. If we adopted the lower luminosity of the later star the space motion in Table 2 would be little affected.

HD 81410. The light variation and the variable radial velocity based on observations by Wayman and by Jones, are discussed elsewhere (Eggen 1973) where a period near 25 days was derived. The light variation, of nearly 0.5 mag amplitude, shows changes in form over a longer period. Wayman (unpublished) classifies the star as K1 IV whereas Bidelman and MacConnell (1973) call it K1 III. Wayman notes strong H and K emission lines that give the same velocity as the absorption lines and Bidelman and MacConnell state that the 'Balmer lines are filled'. This system deserves more attention.

HD 83950. This is ADS 7494 but the companion is an optical one (Eggen 1963). However it was earlier noted (Eggen 1967) that the variable shares the proper motion of BD +55°1351, which is about 1° distant; (V, B-V, U-B) = (9.50, +0.97, +0.74) mag for +55°1351. This later star gives a modulus of 2.75 mag, from a main sequence fit, which also places the mean component of the variable on the main sequence, assuming equal components. The spectroscopic results are summarized by Struve and Horak (1950). Determinations of the systemic velocity vary from near 0 to -50 km/sec and a median of -25 km/sec was adopted here.

<u>HD 86590</u>. Four Mount Wilson plates (see Abt 1969) show a large range from -50 to +70 km/sec and four David Dunlap plates, -20 to +100 km/sec. The mean of all plates is +20 ± 60 (σ) km/sec. The photometric observations were made in February and May, 1963 and show a range of 0.08 mag in V. If the mean radial velocity is nearly correct the system may be a member of the Hyades Group. However, in contrast to this result, two observations in March 1978 give (V, b-y, M_1, C_1) = (7.75, 0.545, 0.270, 0.410) mag. Comparison with VB 91 in the Hyades cluster, for which (B-V, U-B, b-y, M_1, C_1) = (+0.88, +0.54, 0.520, 0.325, 0.400) indicates, both through M_1 and U-B, a much lower metal abundance for HD 86590. The visual mag was 7.90 on 2 April 1978.

<u>HD 97528</u>. The spectroscopic data is summarized by Miller and McNamara (1963) who also find M_V near 0 and +2 mag for the A and G type components, respectively. Individual masses of low weight were derived from double D lines on a single plate giving $13_{\odot}$ for A and $2^{\odot}$ for B. Observations in 1961 with the Cape Observatory 18 inch reflector are summarized in Table 4. Those for mid (total) primary eclipse should represent the secondary star. The adopted luminosity for A gives M_V = +2.5 mag for the companion, in agreement with Miller and McNamara. The system may belong to the Hyades Group. Observations in 1978 show a variable Hβ, perhaps caused by emission lines in the A component.

HD 106677. Young (1939) found a variable radial velocity, with a range of 30 km/sec, and strong H and K emission. Bopp et al.(1977) have shown that the lines are double and indicate a period of between 10 and 20 days. They also found a small light variation which may have a longer period. If the mean radial velocity is near the value adopted, the system consists of subgiants in the Wolf 630 Group; the V-velocity reflects 50 percent of the radial velocity.

HD 108102. Kraft (1965, also Weaver 1952) found this object, in the Coma Berenices cluster, to be a double lined spectroscopic binary with equal components and a one day period. Several series of photometric observations indicate that the light variation, if present, amounts to less than 0.05 mag.

+25°2511. Trumpler found a variable velocity with a range of 40 km/sec from 5 plates of this member of the Coma Berenices cluster. Wilson (1963) note sharp, double H and K emission lines. An examination of all available photometry shows a possible range in visual magnitude of over 0.1 mag. This object obviously requires attention.

HD 114519. The available radial velocity data is discussed by Popper (1961) who also gives the individual colors as B-V = +0.44 and +0.91 mag for the primary and secondary, respectively. The adopted luminosity of the bright component was derived by McNamara (1964) from intermediate band (1, c) photometry. The light curve shows variations from cycle to cycle that may be caused by nonuniform flux from the fainter component (e.g. Hall 1972).

HD 118216. The spectroscopic results are discussed by Conti (1967) who found H and K emission lines from the secondary component. Conti also detected the secondary component in UBVRI photometry, finding it to be 2.8 mag fainter than the primary (F4) component in V and with B-V = +1.36 and U-B = +1.91 mag. These colors are nearly identical to those of 61 Cyg B (K7 V). However, this result can not be reproduced in the extensive 13 color photometry by Johnson and Mitchell (1975). The 13 color results for HR 5110 are listed in Table 5 in the form of magnitudes; the effective wavelengths are essentially 10^2 x filter number. The magnitudes of HR 9072, a subgiant of type F4, are also shown in Table 4 after they were normalized to the 52 magnitude of HR 5110. The energy distributions in the 2 stars are remarkably similar from 3000 to 11000 Å. If we added a 61 Cyg B, which was 2.8 mag fainter than HR 5110 at 52, it would be only about 0.5 mag fainter at 110 and completely destroy the agreement with HR 9072 seen in Table 4. From the assumption that the F star has $1.5_{\odot}$, and the mass ratio from the orbit, Conti finds $0.4_{\odot}$ for the fainter star. This corresponds to M_V near +9 mag for a main sequence star (Eggen 1974). Strömgren photometry (Danziger and Faber 1971) indicates that the F star is about 1.8 mag above the main sequence, or M_V near +1.6 (Eggen 1971), making the magnitude difference between the components near 7.5 mag in the visual. The red component is then only slightly less luminous than 61 Cyg B and the energy distribution given by the 13 color photometry for 61 Cyg B indicates that it would still be more than 5 mag fainter than the F star at 110. The small, but high weight Allegheny trigonometric parallax, 0.019 (wt.28) arcsec, leads to $M_V = +1.4$ mag for the bright component, which agrees very well with the photometric determination.

HD 128171. The Mount Wilson spectroscopic results are listed by Abt (1973) and the systemic velocity in Table 1 was estimated from this material. The proper motion from the Yale Zone Catalogue has a probable error of 0.012 arcsec. Two observations in March 1978 gave $(V, b\text{-}y, M_1, C_1) = (9.50,$ $0.690, 0.370, 0.355)$ mag at phase 0.017, near midprimary eclipse, and (9.14, 0.675, 0.310, 0.365) mag at phase 0.170, just after primary eclipse. These results indicate little difference between the components which match the indices of subgiants in the Arcturus Group (Eggen 1978; [Fe/H] near -0.6).

HD 150708. From observations obtained at total eclipse (Eggen 1963a) the individual components of the eclipsing system were found to have (V, B-V, U-B) = (9.49, +0.97, +0.63) mag and (9.00, +0.65, +0.11) mag for the fainter and brighter stars, respectively. The variable is the A component of ADS 10152 (8"); B has (9.67, +0.57, +0.05) mag and spectral type F8 V. The eclipsing components have near equal mass (Joy 1941, Eggen 1955). The visual companion gives a modulus of 5.0 mag (Eggen 1963a).

HD 155555. Bennett, Evans and Laing (1962) found double lines, nearly equal mass components and a period of 1.687 days. Stoy (1963) gives (V, B-V) = (6.67, +0.80) mag. However, two observations in 1973 with the Siding Spring 1 m reflector give (V, B-V, U-B, R, R-I) = (6.83, +0.835, +0.29, 6.46, +0.325) mag. The star is also the A component of LDS 587 and the results for B are (12.82, +1.54, +1.05, 11.40, +1.205) mag. The companion is 33 arcsec distant but even if it was included by Stoy it could not explain the observed magnitude difference, and the bright star is apparently variable. The (UBV) results indicate a very large ultraviolet excess and a comparison of B-V with R-I indicates an IR excess. If we fit the (R-I) of the faint companion to the young disk main sequence, we obtain a modulus of 1.1 mag, which places the bright star (assumed to be composed of equal components) also near the main sequence: the resulting parallax is 0.06 arcsec. The resulting space motion is that of a young disk star and is similar to that for HD 81410 above. Although Bennett et al. state that eclipses were searched for and no light variation found, the large difference in the available V magnitudes indicates that further photometric work is desirable.

HD 163930. Popper (1956) has discussed the spectroscopic and photometric results, deriving near equal masses for the two components and B-V = +0.48 and +0.91 mag for the bright and fainter, respectively. The system is a member of the Hyades Group (Eggen 1960), giving a modulus of 3.4 mag. This modulus also places the F star on the Hyades main sequence and gives M_V = +5.2 mag for the K star (B-V = +0.91), making it similar to the well determined value for the components of HR 1099A discussed above and strengthening the argument for group membership of HD 86590, also discussed above.

+22°3245. Spectroscopic elements for this double lined system of equal subgiants (G8 IV) have been published by Imbert (1971). The photometry in Table 1 is based on two observations at maximum light in 1960 with the 100 inch Mount Wilson reflector. A third observation near minimum light shows only a small increase in both B-V and U-B. A third star, some 18 arcsec distant, gives (V, B-V, U-B) = (13.50, +0.57, 0.00) mag from three observations. If the faint star is a main sequence, common proper motion companion to the variable, the modulus of the system is 8.9 mag and the equal components of the variable have M_V near +1.3 mag. It seems likely that the faint star is an optical companion only. The adopted modulus is based on the similarity of the components to those in HR 1099 A.

HD 166181. Nadal, Pedoussant and Ginestet (1974) give the spectroscopic elements for this single lined binary, discuss the variation between the H and K line velocities and those from the absorption lines, and derive the luminosity in Table 2 from the H and K emission widths. Eight observations with the Palomar 20 inch reflector in 1962 (January to August) show a variation of 0.1 mag in V. More photometry is required.

HD 175742. Four Mount Wilson plates show a total range of 95 km/sec in the radial velocity (see Abt 1973). The Allegheny parallax, 0.041 (wt.28) arcsec, gives M_V near +6.4 mag and the star is probably a main sequence object.

HD 178450. Four Mount Wilson plates show a total range of 40 km/sec (see Abt 1973) and five from the David Dunlap Observatory (Heard 1956) show a range of 65 km/sec; the mean velocity is 0 ± 23 (σ) km/sec. The photometry is the result of a single observation in 1962.

HD 179094. Young (1944) derived the spectroscopic orbit with a period of 28.6 days. Herbst (1973) suspected light variations with an amplitude near 0.05 mag that may not be correlated with the spectroscopic period. Young and Koniges (1977) find $M_V = -1.2$ mag from the H and K emission widths but this may be too bright, although the CN measurements by Griffin and Redman (1960) are consistent with those for a giant star.

HD 196925. Three Mount Wilson plates (see Abt 1973) give a range of 15 km/sec in the velocity. The companion is +80°662 and has the same proper motion as the bright star (Eggen 1963a). Fitting the companion to the main sequence gives a modulus of 3 mag, or $M_V = +3$ mag for HR 7098, which agrees well with +2.9 mag derived by Wilson (1976) from the H and K emission widths. Apparently the Mount Wilson classification as a subgiant is more correct than K0 III assigned by Stephenson (1960). Stephenson calls the B component of type F8 V. Both components show nearly 0.2 mag ultraviolet excess, which, in the case of A, may result from the spectroscopic companion.

HD 200391. The photometric and spectroscopic observations are discussed by Northcott and Bakos (1967) and the H and K emission noted by Bond (1970). The vagaries of the light curves are similar to those for SV Cam and RT And.

<u>HD 206031.</u> The spectroscopic elements were derived by Sanford (1942) who confirmed the suspicions of Jones (1918) that the systemic velocity shows a small variation in a long (20 years?) period. The luminosity in Table 1 is based on membership in the Wolf 630 Group (Eggen 1978); Wilson (1976) finds M_V = +2.1 mag and Young and Koniges (1977) find +2.5 mag for H and K emission widths and the mean trigonometric parallax gives +2.6 mag.

<u>HD 209318.</u> The near equal components are subgiants of type G9 and K1 (Joy 1931). The photometry is based on a single observation at maximum light. The light curve is variable in form (Milone 1968) and the system shows an infrared excess (Milone 1976). A luminosity of M_V = +3 mag gives a space motion nearly identical to that of 61 Cyg (Eggen 1978).

<u>HD 210334</u>. The radial velocity and spectra of the equal components in this eclipsing binary are discussed by Sanford (1951). The photometry is based on 3 observations outside of eclipse in 1962. Chambliss (1976) finds (V, V-B, U-B) = (6.75, +0.93, +0.58) mag at the total, primary eclipse and this result will be assumed to apply to the primary star. One of the earliest suggestions that the light curves of this and other variables subject to 'distortions' caused by star spots was made by Kron (1959).

A detailed discussion of the spectrum is given by Naftilan and Drake (1977), who find the primary has solar abundance but that the secondary is underabundant. Naftilan (1975) found the same result for HD 114519 (RS CVn). The adopted luminosity in Table 2 gives the system the space motion of the Wolf 630 Group. However, even if a group member, the luminosity is indeterminate by this means because the V-velocity is a reflection of the radial velocity only.

HD 213389. This single lined spectroscopic binary is discussed by Northcott (1947) who also finds a spectroscopic luminosity of $M_V = +2.2$. Herbst (1973) discovered a light variation with an amplitude of 0.13 mag phased, in a double wave, with the orbital period.

HD 216489. The single lined spectroscopic orbit is discussed by Harper (1920). Herbst (1973) found a light variation with an amplitude of 0.16 mag that is out of phase with the orbital period. The assumed luminosity is that of the very similar star HD 213389 (above).

+52°3383a. Payne-Gaposchkin (1946) found a double lined spectrum with near equal components. The light curve and its instabilities are discussed by Gordon (1955). A more detailed spectroscopic study is badly needed.

HD 219113. Jakate, Bakos, Fernie and Heard (1976) have discussed the photometry and spectra of this object. They find double lines from stars of near equal mass with the late type object being slightly the more massive, as true for most of the stars discussed above. From the photometry of Jakate et al. the late type star has (V, B-V, R-I) = (7.65, +0.99, +0.415) mag from the apparently total eclipse leaving (8.15, +0.35, +0.1:) mag for the F star. The main sequence luminosity for the F star is then M_V = +3 mag, which agrees well with the estimate of Jakate et al.

HD 222107. Radial velocity and H and K emission observations are summarized by Gratton (1950). From the H and K emission widths Wilson (1976) finds values of M_V ranging from +2 to 0 mag but the high weight, trigonometric parallax of 0.043 (wt.24) arcsec gives M_V = +2.2 mag. Many series of observation show small light variations of over 0.25 mag in a period near 50 days.

HD 224085. The available radial velocity data is summarized by Halliday (1952). The available photometry indicates a variation in the visual magnitude of some 0.1 mag. The high weight Allegheny parallax, 0.039 (wt.28) arcsec, gives M_V = +5.5 mag, placing the star some 1.5 mag above the main sequence value for the observed B-V, or over 2 mag for the observed R-I. The resulting space motion is very similar to that of Epsilon Eri with which HD 224085 makes an interesting contrast; Epsilon Eri has essentially the same B-V as HD 224085 but it is classified K5 V and has U-B = +0.98 mag and R-I = +0.405 mag. The system of HD 224085 may be similar to HD 128171 (RV Lib) and a search for the secondary component in the spectrum may be warranted. Rucinski (1977) has published a recent photometric study and noted the presence of λ6706 (Li) in the spectra.

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Table 1

Close binaries of F, G and K types dwarfs and subgiants with H and K emission

Name	HD	V Mag	B-V Mag	U-B Mag	R-I Mag	P (days)	ρ (km/sec)	μ_α (0".001)	μ_δ
HR 3	28	4.6 Var	+1.05	+0.90	+0.39	72.9	-6.1	-13	+89
HR 215	4502	4.0 Var	+1.10	+0.90	+0.41	17.8	-23.7	-98	-82
	5303	7.7 Var	+0.67	-	-	1.8	0:	-238	+22
HR 645	13530	5.32	+0.93	+0.62	+0.34	1650.	+27.3	+355	-171
LX Per	19845	8.1 Var	+0.75	+0.28	-	8.0	+27.0	+45	-68
UX Ari	21242	6.26	+0.95	+0.47	-	6.4	+26.5	+38	-107
HR 1099 A	22468	5.8 Var	+0.92	+0.43	+0.39	2.8	-14.0	-29	-62
HR 1176	23838	5.80	+0.70	-	+0.29:	-	+15:	-39	-24
V 471 Tau	+16°516	9.71	+0.92	+0.59	+0.355	0.5	+36.8	+117	-22
	27130	8.34	+0.775	+0.33	+0.29	5.6	+38.2	+118	-2
	27149	7.52	+0.68	+0.25	+0.215	75.6	+39.6	+114	-28
RZ Eri	30050	7.70	+0.65	+0.35	-	39.3	+32.0	+21	-6
SV Cam	44982	8.68	+0.72	+0.46	-	0.6	-13.0	+44	-147
HR 3119	65626	6.49	+0.625	+0.165		11.1	+25.8	+30	-62
TY Pyx	77137	6.85	+0.685	+0.26		3.2	+63.2	-54	-49
	81410	7.4 Var	+1.05	+0.70	+0.45	25.4:	0:	+37	-33
W UMa	83950	7.7 Var	+0.66	+0.08		0.33	-25:	+21	-24
	86590	7.7 Var	+0.88	+0.43			+20:	-242	-46
TT Hya	97528	7.2 Var	+0.185	0.00		7.0	+10.5	-26	+7
HRY 665	106677	5.4				10-20	-47:	-21	-38
	108102	8.15	+0.50	0.00	+0.19	1.0	-0.4	-10	-16
	+25°2511	9.7 Var	+1.09	+0.80	+0.30	-	(0.0)	-11	-22

Table 1 (continued)

Close binaries of F, G and K types dwarfs and subgiants with H and K emission

Name	HD	V Mag	B-V Mag	U-B Mag	R-I Mag	P (days)	ρ (km/sec)	μ_α (0".001)	μ_δ (0".001)
RS CVn	114519	8.2 Var	+0.59	+0.09		4.8	-15.0	-49	+4
HR 5110	118216	4.96	+0.38	+0.05	+0.19	2.6	+7.4	+84	-9
RV Lib	128171	9.0 Var	+1.02	+0.65		10.7	-30:	-22	-26
WW Dra	150708	8.6 Var	+0.72	+0.21		4.6	-28.5	+12	-61
	155555	6.8 Var	+0.835	+0.29	+0.325	1.7	+2.3	-8	-133
Z Her	163930	7.3 Var	+0.59			4.0	-46.0	-22	+70
	166181	7.6 Var	+0.72	+0.13		1.8	-13.4	+115	-27
MM Her	+22°3245	9.5 Var	+0.84	+0.39		8.0	-50.8	+2	-34
	175742	8.4				-	-6:	+125	-288
	178450	7.63	+0.73	+0.21		-	0:	+110	+115
HR 7275	179094	5.80	+1.10	+0.86		28.6	+4.2	-106	-53
HR 7908	196925	5.98	+0.98	+0.60		-	-14:	+75	+221
ER Vul	200391	7.3 Var	+0.60			0.7	-25.2	+95	+7
HR 8283	206031	5.19	+0.665	+0.15	+0.24	13.1	-1.2	-123	-307
RT Lac	209318	8.9 Var	+1.10	+0.90		5.1	-47.5	+66	+37
AR Lac	210334	6.1 Var	+0.75	+0.29	+0.33	2.0	-36.0	-48	+55
HR 8575	213389	6.40	+1.15	+1.00		17.8	+5.4	-24	-29
HR 8703	216489	5.70	+1.10	+0.90		24.6	-12.3	-11	-29
RT And	+52°3383a	8.9 Var	+0.56			0.6	+20:	-1	-11
SZ Psc	219113	7.2 Var	+0.84		+0.35	4.0	+8.8	-1	-35
HR 8961	222107	3.8 Var	+1.00	+0.70	+0.40	20.5	+6.8	+162	-420
	224085	7.4 Var	+1.0-	+0.66	+0.50	6.7	-18.1	+546	+31

Table 2

Luminosities and Motions of Stars in Table 1

HD	Mv Mag	S	U	V (km/sec)	W	Sp
28	+2.4	OCW	+4	+12	-1	K0 III
4502	+1.9:	π	-24	-14	+7	K0 III
5303	+3.6	61 Cyg	+93	-53	-6	G2V + F0
13530	+2.4	OCW	+67	-33	-14	G9 III
19845	+3.6	HK	+40	-17	-21	G5 IV, G5 IV
21242	+2.5	Sp	+26	-20	-17	G8 IV
22468 A	+4.6	Cp	-23	-10	-2	G5 V
23838	+3:	-	+12	+9	-9	G0
+16°516	+6.35	Hy	+42	-17	-4	K0 V
27130	+5.6	Hy	+44	-17	+4	G8 V
27149	+5.0	Hy	+43	-17	-3	G2 V
30050	+0.6	$\Delta[c_1]$	+25	-39	+3	A_m+G8
44982	+4	-	+57	-61	-14	G3
65626	+3.5	HK	+22	-9	+20	F8
77137	+3.9	Orbit	+19	-63	-6	G2-5
81410	+3:	-	+3	-9	-28	K1 IV
83950	+5.6	Cp	-18	-9	-15	F8
86590	+5:	L	+41	-18	-10	K0 V
97528	-0.15	Hy	+36	-17	+1	A3 + G6
106677	+3.0	W630	-19	-33	-28	K0
108102	+4.4	CB	0	-7	-1	F8 V
+25°2511	+6.0	CB	-1	-9	-1	G9 V
114519	+3.2	c, ℓ	+20	-14	-14	F4, G

Table 2 (continued)

Luminosities and Motions of Stars in Table 1

HD	M_V Mag	S	U	V (km/sec)	W	Sp
118216	+1.6	$\Delta[c_1]$	-16	+12	+4	F2 (IV)
128171	+3.5:	-	+26	-14	-25	G2
150708	+3.9	Cp	-30	-23	-17	Sg G2, Sg KO
155555	+5.7	Cp	+5	-8	-6	G5 IV, KO
163930	+4.3	Hy	+44	-17	-4	F4 V, KO
166181	+5.2	HK	+3	+5	-42	G5 V
+22°3245	+4.6	-	+15	-46	-27	G8 IV, G8 IV
175742	+6.4	π	-19	-15	-29	dK1
178450	+5.5	pt.	+17	+10	-6	G8 V
179094	+2:	-	-21	-5	+20	K1 IV
196925	+3.0	Cp	+33	-32	-1	Sg G8
200391	+4.5:	-	+23	-23	-10	GOV, G5V
206031	+3.0	W630	-24	-33	-1	G2 IV
213389	+2.2	Sp.	-11	+7	-5	K2 III-IV
216489	+2:	-	-5	-12	+6	K1 III-IV
+52°3383a	+4:	-	+3	+19	-7	F8 V
219113	+3.0	M.S.	+7	+18	+2	F8V, K1IV
222107	+2.2	π	+1	-6	-48	G8 III-IV
224085	+5.4	π	+54	-41	-2	KO V

Table 3

Comparison of three systems

Star		B-V Mag	U-B Mag	R-I Mag	M_V Mag	P days
ADS 2644	A	+0.92	+0.43	+0.39	+3.85	2.8
	B	+0.99	+0.79	-	+6.8	-
RU Peg	A	+0.95:	+0.7:	+0.36	+6.6	0.4
	B	+0.81	+0.46	+0.30	+6.1	
V 471 Tau		+0.92	+0.59	+0.355	+6.35	0.5
VB 5		+0.99	+0.81	+0.34	+6.4	

Table 4

Observations of TT Hya

Phase	V Mag	B-V Mag	U-B Mag	N
0.580	7.30	+0.13	0.00	2
0.000	9.02	+1.015	+0.55	2
0.155	7.25	+0.185	0.00	2

Table 5

13 Color Results for HR 5110 and 9072

HR	33 Mag	35 Mag	37 Mag	40 Mag	45 Mag	52 Mag	58 Mag
5110	5.397	5.302	5.365	5.494	5.273	5.068	4.872
9072	5.386	5.285	5.345	5.509	5.286	5.068	4.835
Δm	+0.011	+0.017	+0.020	-0.015	-0.013	0.000	+0.037
HR	63 Mag	72 Mag	80 Mag	86 Mag	99 Mag	110 Mag	Sp
5110	4.701	4.595	4.454	4.406	4.333	4.268	F2 (IV)
9072	4.691	4.553	4.444	4.414	4.373	4.284	F4 (IV)
Δm	+0.010	+0.042	+0.010	-0.008	-0.040	-0.016	

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