General Electric Research Laboratories and the Bell Telephone Laboratories for providing samples of silicon.

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## Finley-Freundlich Red-Shift Hypothesis

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In view of the possible serious physical implications[1,2] of the Finley-Freundlich hypothesis[3] that light, passing through an enclosure of energy density $u=bT^4$ and dimension $h$, suffers a red shift $\Delta\lambda/\lambda=AT^4h$ ($A=2\times10^{-29}$ cgs units), it appears desirable to state here two astronomical arguments preventing acceptance of this proposal unmodified.

Consider an eclipsing binary star system ($i=90°$) in which the relative orbit is circular with radius $a$. Take $u_i=b_iT_i^4$ as the energy density at the surface of star $i$, the radius of which is $R_i$. The energy density in space at a point at distance $h$ from star $i$ is $u=u_iR_i^2/h^2$. If $\theta$ is the angle introduced in Fig. 1, the integrated energy density along the line of sight towards star 2, due to its companion's presence,[4] is $U_2=(u_1R_1^2/a)[(\pi-\theta)/\sin\theta]$, outside of eclipse. A change in the total energy density along the line of sight of many times $u_1R_1^2/a$, would occur in a single revolution. The quantity $u_1R_1^2/a$ corresponds to a predicted Freundlich shift of amount $\Delta V=cAT_1^4R_1^2/a$.

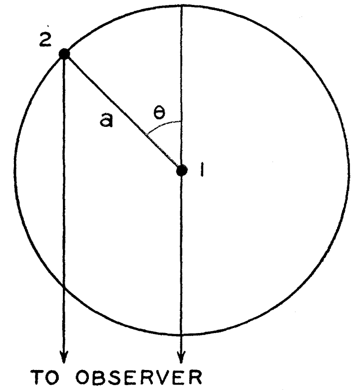


FIG. 1. A typical binary system.

Table I contains the predicted $\Delta V$, together with other quantities of interest for five systems selected from the *Fourth Lick Catalog of Spectroscopic Binaries*,[5] Although there exists a slight uncertainty in spectral types and consequently in temperature, the predicted effect is certainly orders of magnitude too large and one can afford to be slightly uncritical of the observational data. Use of more recent spectral classifications[6] decreases $\Delta V$ by only 50 percent for the fainter star in *TX* Herculis, and not at all for the fainter star in *Z* Vulpeculae. The data for the system *Y* Cygni are particularly reliable.

It may be maintained that the hypothesis holds only in the presence of matter, the above argument then not being conclusive since the presence of matter in the orbital plane has not been demonstrated.

The unusual system of $\epsilon$ Aurigae[7] provides a natural test of this further possibility. While objections[8,9] have been raised to parts of the interpretation of this system,

TABLE I. Data for five systems. Column 1 gives the Fourth Lick Catalog number, Column 2 the star name, Column 3 the spectral type (*HD* Rev.) of each component (in all cases listed the spectral type being the same for both components), Column 4 the effective temperature corresponding to the spectral type, Column 5 the mean radius of the two components, the solar radius being taken as unity, Column 6 the semimajor axis of the relative orbit using the same unit of length, Column 7 the percentage contribution of each star to the total luminosity of the system, Column 8 the semiamplitudes of the two radial velocity curves, and Column 9 the predicted $\Delta V$. In all cases the inclination of the orbital plane exceeds 86.5°.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| No. | Star name | Type | Eff. temp. °K | Mean rad. | Semi-major axis | Lumin. contrib. percent | Semi-amplitudes km/sec | $\Delta V$ km/sec |
| 78 | *TT* Aur. | *B3* | 18 000 | 4.3 | 11.7 | 68; 32 | 197: 246 | 70 000 |
| 115 | *WW* Aur. | *A7* | 8 000 | 2.1 | 12.5 | 55; 45 | 116; 135 | 610 |
| 251 | *TX* Her. | *A2* | 10 000 | 1.6 | 10.7 | 64; 36 | 121; 140 | 1 000 |
| 296 | *Z* Vul. | *B3* | 18 000 | 4.3 | 15.1 | 75; 25 | 96; 214 | 54 000 |
| 322 | *Y* Cyg. | *O9* | 25 000 | 5.9 | 28.4 | 50; 50 | 245; 241 | 200 000 |

it still appears quite probable that during the eclipse, the light of the *cF* star passes *through* the outer part of its companion *I* star. During eclipse ionized lines arising from the outer parts of the *I* star indicate the presence of gaseous material. At eclipse, we therefore have the ideal situation of a long path length though matter in the presence of a radiation field.

If one uses the Yerkes model,[7] the maximum dip of the *cF* star below the *I* star's edge is $2.4\times10^{13}$ cm and the radius of the *I* star is $2\times10^{14}$ cm. If the *I* star was perfectly spherical, the *F* star's light would travel along a chord of the *I* star, $2\times10^{14}$ cm long. If one uses $T_I=1200$°K, the predicted $\Delta V$ is 2400 km/sec. Judging from the observations, this is at least 200 times too large. If the path length is chosen so as to be equal to the effective length over which optical absorption occurs,[7] $\Delta V$ is decreased by a factor of ten. It is to be noted that the temperature used for this calculation is

quite conservative, the considerable ionizing radiation emanating from the *cF* star being ignored.

It is to be noted that ζ Aurigae systems such as the prototype and *VV* Cephei provide means for similar tests, and that Struve[10] has already pointed out the possibility of interpreting the observational bases of this theory by more conventional mechanisms.

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## *K* Band in Additively Colored KCl

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THE *F*-band absorption in alkali halides is accepted to be the result of a 1*s*-2*p* transition of an electron trapped at a negative ion vacancy in the lattice. Mott and Gurney[1] first suggested that the shoulder on the high-energy side of the *F* band (the *K* band[2]) was associated with 1*s*-*np* transitions and transitions to the ionization continuum. Dexter[3] has calculated the absorption cross section per electron at the *F* band, and at its presumed series limit using hydrogen like wave functions. No evidence has been presented definitely to contradict the assumption that the *K* band is an integral part of the *F* band, and for this reason the most recent review article on color centers[4] maintains this point of view. The data presented here indicate that the ratio of the absorption of the *F* and *K* bands is not a constant. Therefore the two bands are not a result of transitions from the ground state of the same center.

The KCl crystals used in the room temperature work were high purity crystals grown by the Kyropoulos technique. The crystals were additively colored at 600°C in potassium vapor. Next, thin crystals which were cleaved for absorption measurements (made in the Beckman Model DR Spectrophotometer) were wrapped in a light tight aluminum foil and heated to 500°C. After allowing sufficient time for the dispersal of any aggregate or colloidal bands the crystals were quenched. Curve *a* of Fig. 1 shows the absorption obtained without exposing the crystal to light. Curves *b*, *c*, *d*, and *e* were obtained after subsequent exposures of the same crystal to light of wavelengths greater than 5000A. The crystals used for the liquid nitrogen data were Harshaw crystals colored at 477°C for 28 hours, quenched immediately to room temperature and measured in a Cary automatic recording spectrophotometer. Curve *a* of Fig. 2 shows the absorption of the crystal measured at −160°C prior to bleaching. In curve *b* the same crystal after irradiation into the *F* band at +50°C, is measured again at liquid nitrogen temperature. The Cary spectrophotometer was used as a monochromator with a slit width of 1.5 mm or about 250A. Both sets of curves show after irradiation a partial bleaching of the *F* band and an unexpected growth of the *K* band. The $R_1$, $R_2$, *M*, and *N* bands grow as expected at room temperature, but at 50°C the $R_1$ and $R_2$ bands appear to decrease while the *M* band increases.

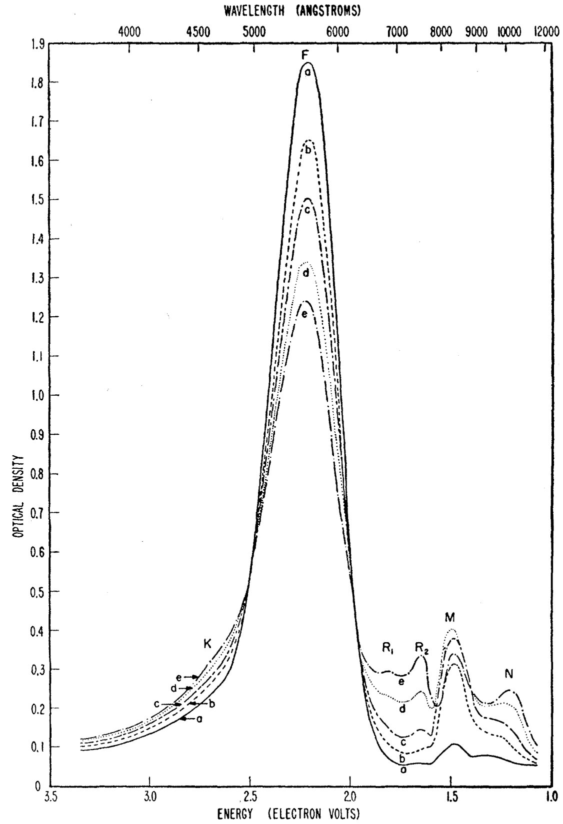


Fig. 1. A sequence of absorption measurements at room temperature of additively colored KCl (~$4\times10^{17}$/cc). Irradiation made with a tungsten lamp through a Corning No. 3482 filter. Curve (*a*), no optical bleach; (*b*), illuminated 20 seconds; (*c*), 40 seconds; (*d*), 100 seconds; (*e*), 220 seconds.

The data presented here do not yet allow a description of the *K* center, but indicate that the center is not due to a transition of an electron in the ground state of the *F* center to excited states or to the conduction band. It should be pointed out that the data of Molnar[5] indicate that the *K* band grows as the *F* band is bleached, but apparently no significance was attached to the increase in absorption in the *K* band region. It is unlikely that