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FIBER-OPTIC ECHELLE CCD OBSERVATIONS OF SS BOOTIS

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ABSTRACT

We have observed the faint RS CVn system SS Bootis over two seasons and have examined the most prominent surface activity indicators in this spectroscopically understudied object. The first two Balmer lines are consistently strongly in emission, as are the Ca II infrared triplet and Ca II H line; there is no significant modulation with phase in any of these lines. No excess emission is evident in He I D_3. The ratio of energy emitted in Hα to that in Hβ is typically between three and six for the more active subgiant primary, and between two and five for the dwarf secondary. Of special interest is an excess absorption feature in the Balmer lines near primary eclipse in both seasons. The feature lies near the velocity of the secondary, and as there is no similar feature in secondary eclipse, we suggest that it arises from obscuring material associated with the primary. From the extent of the feature and the system's geometry we have placed limits on the parameters of such material.

Subject headings: stars: eclipsing binaries — stars: emission line — stars: individual (SS Boo)

I. INTRODUCTION

SS Boo is a double-lined RS CVn binary, exhibiting pronounced emission in its Ca II H and K and Balmer lines and showing the anomalous distortion wave in its light curve produced by starspots on the surface, in accordance with the definition of Hall (1976). The K1 IV primary and G0 V secondary, each of mass 1.00 $M_{\odot}$, orbit with a period of 7.606 days (Hall and Kreiner 1980) at an orbital inclination of $i = 88^{\circ}.8 \pm 0^{\circ}.3$ (Wilson *et al.* 1983); the system is therefore totally eclipsing. A summary of the system parameters appears in Table 1.

Less attention has been paid to SS Boo than to some other RS CVn systems, as it is quite faint ($V_{max} = 10.3$, Popper and Ulrich 1977). Photometry done during the 1970s established the migration of the distortion wave as consistent with the familiar "butterfly" spot cycle on the primary (Hall and Henry 1978), but subsequent photometric investigations have revealed that the rate and direction of migration and the amplitude of the wave are quite erratic, including a sudden halt in migration around epoch 1981.0 (Wilson *et al.* 1983). They suggest that this arose from short-term phenomena associated with the numbers and temperatures of the individual spots in addition to long-term cyclic variations of the entire spot group. The nature of the wave in SS Boo is still unclear, since the typical method for studying the migration, which is to plot the phase of wave minimum, ϕ_{min}, over time, suffers from the difficulty that ϕ_{min} can be displaced by an integral phase and yield the same result. Busso, Scaltriti, and Cellino (1985) plot the progression of ϕ_{min} with time with certain points displaced by $\pm 1^{P}.0$, obtaining two fairly well-defined spot cycles over the past two decades, although the rapid wave migration this implies has not been confirmed and the authors themselves do not posit the results to be conclusive.

Walter and Bowyer (1981) found X-ray emission $L_X = 6.31 \times 10^{30}$ ergs s^{-1}. This follows the relationship they observed for RS CVn stars in general, namely that L_X/L_{bol} increases with decreasing orbital period, which supports the dynamo model for activity in RS CVn systems (i.e., that the higher magnetic flux in high angular velocity systems produces greater activity in the chromospheres and coronae). Drake, Simon, and Linsky (1989) observed SS Boo at 6 cm and claim a detection of 6 mJy, although they note a slight positional discrepancy.

Our purpose was to obtain optical spectra of this system to study the characteristics of traditional RS CVn surface activity indicators; herein we present results for the Hα and Hβ lines, the Ca II H line, two lines of the Ca II infrared triplet, and the He I D_3 line from 11 such spectra taken in the spring of 1987 and 1988.

II. OBSERVATIONS AND REDUCTION

Our observations were made with the Penn State fiber-optic echelle (FOE) spectrograph at Kitt Peak National Observatory. A summary of these observations appears in Table 2. The cross-dispersing spectrograph imaged 34 orders onto an RCA3 charge-coupled device (CCD) covering the spectral range from about 390 nm to 900 nm at a resolution of 12,000 (Ramsey and Huenemoerder 1986). Spectra were obtained in each season for the system near quadrature and near primary and secondary eclipses.

We reduced the raw spectra using a software package developed by Rosenthal (1986) for obtaining one-dimensional spectra from a CCD with numerous spectral orders imaged onto it, as with the Penn State FOE. For calibration and

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TABLE 1

SS Bootis System Parameters

Parameter	Primary	Secondary
Spectral types	K1 IV	G0 V
$M/M_{\odot}$	1.00	1.00
$R/R_{\odot}$	3.28	1.31
V_{rot} (km s^{-1})	22	8.8
Approximate orbital velocity	71 km s^{-1}	
Separation of components	21.6 $R_{\odot}$	
Orbital inclination	88°8 ± 0°3	
Period	7^{d}6061412	
Midprimary eclipse (JD)[a]	2,444,332.0335 ± 0^{d}0005	

[a] Primary eclipse is defined as $\phi = 0.000$ = that phase when the secondary is eclipsed by the primary.

analysis, we used the Image Reduction Analysis Facility (IRAF)[3] on a Sun 3/50 workstation at Penn State.

Our method for studying emission features in SS Boo assumes that each component produces an underlying quiescent spectrum with chromospheric excess in active lines superposed. This concept of separating the composite spectrum into discrete components suggests that the excess flux may be isolated by subtracting a "standard star" spectrum from that of the active star, a "standard" being a quiescent star (one with low K-line flux) of the correct spectral type, thus leaving any anomalies isolated in the subtracted spectrum. A more complete discussion of this technique appears in Barden (1985).

Following the spectral types defined for SS Boo by Popper (1980), we chose χ Her (HR 5914) and κ CrB (HR 5901), inactive G0 V and K1 IV stars, respectively. We normalized all continua of the RS CVn and the standards to unity, and then artificially shifted, rotationally broadened, and weighted several inactive orders of the standards until their composite spectrum matched that of SS Boo, using a software package developed by Barden (1985). We therefore obtained radial and rotational velocities and spectral contribution by component for SS Boo for the various phases observed. As a check, we subtracted out Earth's motion and the radial velocities of the standards; the resulting radial velocity curve matched the true space motion of SS Boo (we obtained $V_{rad} = -48.4 \pm 1.6$ km s^{-1}, compared with the true $V_{rad} = -48$ km s^{-1}, Batten *et al.* 1978), with amplitude precisely as expected if established system parameters are correct (e.g., Wilson *et al.* 1983). Table 3 lists our derived radial velocities and spectral contributions by phase. We then subtracted the composite quiescent spectrum, properly shifted, broadened, and weighted, from the active orders. Any excesses necessarily arise from excess chromospheric activity relative to the standard.

Implicit in our approach is the assumption that RS CVn systems do in fact have an underlying quiescent component in their spectra, arising in the photosphere and inactive chromosphere. This will not be true if the active regions are of unusually large extent, but it will hold for more localized regions, and since we are examining relative strengths of emission equivalent widths and modulations with phase on a single system, consistent use of this method will be valid.

[3] IRAF is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation.

TABLE 2

SS Bootis Observing Log

UT Date	Phase
1987 Apr 8	0.820
1987 Apr 9	0.952
1987 Apr 10	0.081
1987 Apr 11	0.203
1987 Apr 13	0.469
1988 Apr 30	0.821
1988 May 1	0.953
1988 May 2	0.091
1988 May 3	0.214
1988 May 4	0.350
1988 May 5	0.480

TABLE 3

Derived V_{rad} (km s^{-1}) and Spectral Weights

ϕ	V_{rad} (K1 IV)	V_{rad} (G0 V)	Wt (K1 IV)
0.081.........	−16.3	−83.5	0.49
0.091.........	−9.8	−85.0	0.51
0.203.........	17.3	−11.3	0.52
0.214.........	15.2	−117.1	0.52
0.350.........	7.4	−101.4	0.52
0.469.........	−47.8	−46.4	0.49
0.480.........	−49.8	−48.5	0.43
0.820.........	−106.0	14.2	0.51
0.821.........	−106.8	9.82	0.50
0.952.........	−50.8	−49.51	0.89
0.953.........	−48.8	−45.51	0.89

Note.—Inaccuracies present in these values, such as the weights at $\phi = 0.081$, are largely due to line blending. The value of each variable (V_{rad}, V_{rot}, and weight) was largely sensitive to the values of the other two at phases approaching eclipse. Weights quoted are from spectral orders in the V band (Hα region). Weight was typically the most troublesome value to extract. Derived values of the radial velocities closely match the true space motion of the system.

III. RESULTS

a) Balmer Line Emission

We consider first the hydrogen emission in SS Boo to obtain initial diagnostics regarding the geometry and origin of its active regions. The significance of the strength and variability of Hα in divining chromospheric extent and structure is discussed in Cram and Mullan (1985), and a study of the ratio of excess emission in Hα and Hβ as an indicator of the phenomena responsible for the emission appears in Huenemoerder, Ramsey, and Buzasi (1990).

SS Boo differs from some RS CVn systems in that its components contribute more or less equally to the net spectrum; Wilson *et al.* (1983) found that the K star contributes about 60% of the light in the V band and 50% in the B band. In addition, the G dwarf is quite active, allowing us to distinguish the components even in phases near eclipse. Values for the excess emission equivalent width (EW) in the active lines can be obtained and analyzed with relative ease for both components.

Figures 1*a* and 1*b* are composites of the subtracted spectra of Hα and Hβ, respectively, plotting wavelength against an arbitrary ordinate where we have progressively offset the spectra to present a single figure for all phases. The spectra are arranged in order of increasing phase; comparison with Table 2 will show that they group into pairs (allowing study of long-term variations at similar phases) with the exception of the

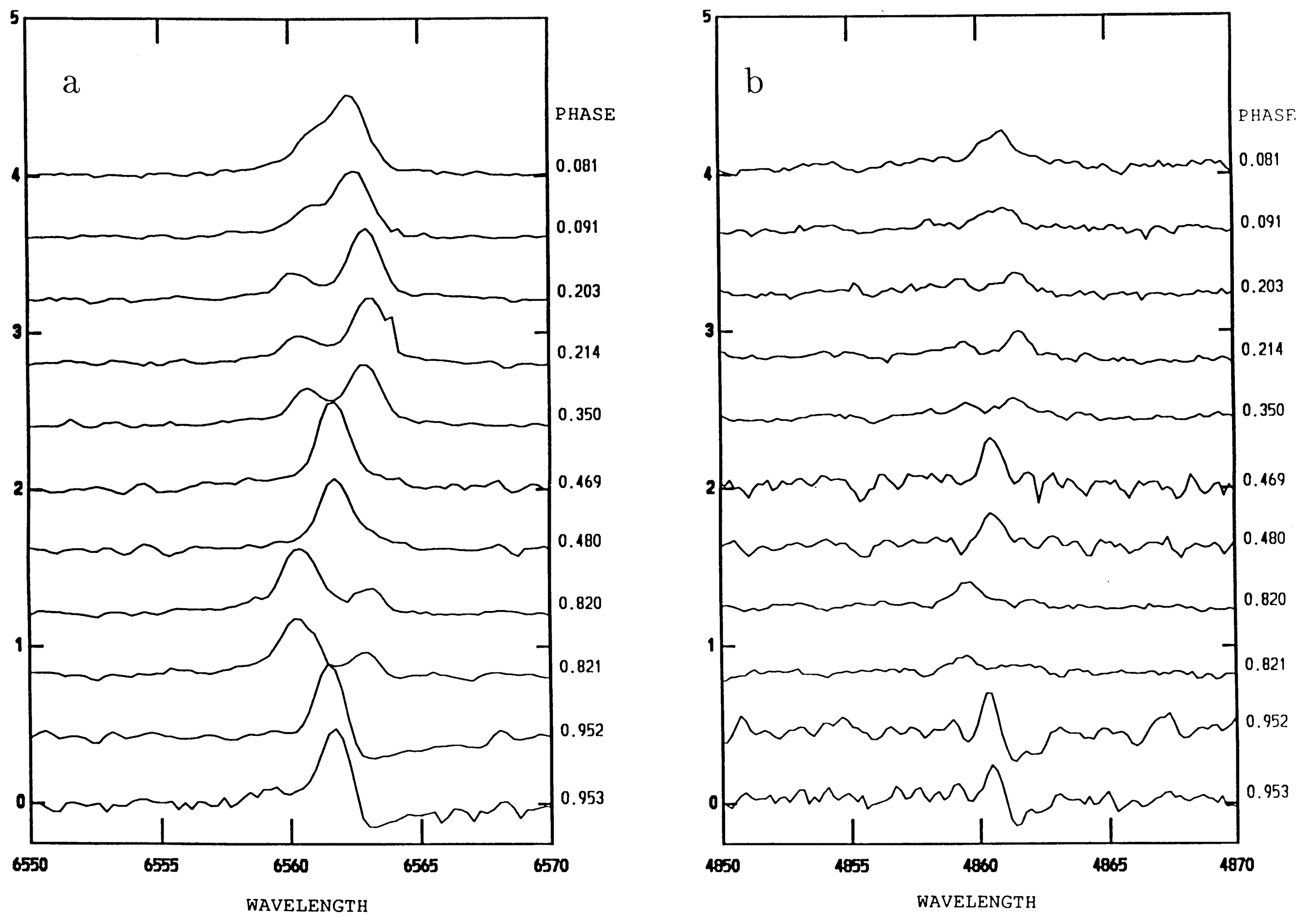

FIG. 1.—Two composite diagrams of the subtracted spectra of SS Boo. (*a*), at left, is of Hα; (*b*) shows the Hβ region. Note the absorption feature in the final two spectra in each region.

$\phi = 0.350$ observation, one of which was lost in 1987 to the vagaries of the weather. The components are clearly visible for all phases except in and near eclipse for both lines. Especially prominent is the absorption feature near primary eclipse ($\phi = 0.952$ and $\phi = 0.953$ in 1987 and 1988, respectively); our interpretation of this will follow. The feature in the primary Hα emission at $\phi = 0.214$ is from a small noise spike in the data and is not real.

We were able to separate the components in both lines for all phases except those near the eclipses. Table 4 lists the excess EW by phase and by component in Hα and Hβ. Modulation of the excess with phase is indicative of the appearance and disappearance of active regions as the stars present different hemispheres to us. SS Boo does not exhibit this, so hydrogen emission does not appear to be associated with the active regions; it arises from global phenomena. There may be some deficit in the emission EW in the secondary Hα around $\phi = 0.82$, but our coverage is inadequate to quantify it. More apparent was the constancy of the emission in both lines. The only significant variations in emission strength between seasons were in the 0.08 and 0.09 phase pair, and these arose more from the degree to which the lines were blended than from genuine changes in the emission EW, as we verified by small adjustments in the deblending parameters.

A useful diagnostic of chromospheric properties is the ratio of intensities $E\alpha/E\beta$, or Balmer decrement. In Figure 2 we plot the excess EW for each component; the slope of the line fitting these points will be proportional to the Balmer decrement by a factor accounting for the relative continuum energies and absolute flux densities in the color bands of interest (*R* and *B* for Hα and Hβ, respectively). For the primary, the average over all phases for this ratio in energy units is 3.64 ± 0.3, while for the secondary it is 2.61 ± 0.6. The values of the emission EW appear in Table 4.

Also significant are the intercepts of these fits; in both cases they lie within 1 σ of zero. This indicates that it is unlikely that we have large zero-point errors fin our data. As discussed by Huenemoerder, Ramsey, and Buzasi (1990), the ratio of energies could be artificially increased at small $W\beta$ if there is a fixed ratio $E\alpha/E\beta$ for a system. Such an artificial trend would appear as increased $W\alpha/W\beta$ at small Hβ EW. The data for SS Boo exhibit no such trend.

To ascribe some significance to our ratios, we recall what various values connote: Tandberg-Hanssen (1967) found that $E\alpha/E\beta$ is typically about 1.5 in the solar chromosphere, decreasing to between 1.3 and 0.83 during flares, while Landman and Mongillo (1979) report values of five to 12 in prominences. Though SS Boo shows undeniable enhancement over quiescent chromosphere figures for both components, the ratios are on the low side for RS CVns, which are more typically between four and eight (Huenemoerder, Ramsey, and Buzasi 1990). Also clear is that $E\alpha/E\beta$ is lower in the secondary

TABLE 4A

BALMER LINE EMISSION EW IN Å BY COMPONENT

ϕ	$H\alpha_{pri}$	$H\beta_{pri}$	$H\alpha_{sec}$	$H\beta_{sec}$
0.081.........	1.01 ± 0.19	0.40 ± 0.09	0.38 ± 0.08	0.09 ± 0.05
0.091.........	0.62 ± 0.07	0.17 ± 0.05	0.54 ± 0.05	0.12 ± 0.04
0.203.........	0.77 ± 0.06	0.12 ± 0.03	0.38 ± 0.07	0.13 ± 0.06
0.214.........	0.75 ± 0.12	0.17 ± 0.04	0.44 ± 0.09	0.15 ± 0.05
0.350.........	0.67 ± 0.06	0.22 ± 0.04	0.49 ± 0.07	0.14 ± 0.03
0.469.........	1.18 ± 0.12	0.25 ± 0.08	*	*
0.480.........	1.01 ± 0.11	0.26 ± 0.07	*	*
0.820.........	0.90 ± 0.09	0.26 ± 0.05	0.24 ± 0.08	0.12 ± 0.05
0.821.........	0.80 ± 0.09	0.12 ± 0.03	0.20 ± 0.07	0.10 ± 0.04
0.952.........	0.62 ± 0.15	0.13 ± 0.09	*	*
0.953.........	0.61 ± 0.14	0.18 ± 0.12	*	*

NOTE.—Several points are worth noting here. It was impossible to deblend the lines in the eclipses; EW at such phases are listed in the columns for the primary, although near secondary eclipse there will be a large contribution from the secondary. The lines at $\phi \approx 0.09$ were still largely blended, and the large variance in EW in the phase pair likely arises from this than from significant physical changes in the system. Values for Hβ will be less accurate overall since there is less signal than at Hα; in addition, the accuracy of the fitting and deblending algorithms is reduced by the many nearby lines.

TABLE 4B

Ca II H AND Ca II IRT EMISSION EW IN Å BY COMPONENT

ϕ	$\lambda\ 8498_{pri}$	$\lambda\ 8498_{sec}$	$\lambda\ 8542_{pri}$	$\lambda\ 8542_{sec}$	Ca II H_{pri}
0.081.........	0.30 ± 0.07	0.12 ± 0.06	0.60 ± 0.14	0.38 ± 0.19	*
0.091.........	0.41 ± 0.05	0.13 ± 0.04	0.40 ± 0.07	0.23 ± 0.04	*
0.203.........	0.54 ± 0.10	0.19 ± 0.07	0.47 ± 0.10	0.28 ± 0.10	0.52 ± 0.28
0.214.........	0.40 ± 0.05	0.21 ± 0.07	0.50 ± 0.04	0.45 ± 0.04	0.72 ± 0.21
0.350.........	0.35 ± 0.04	0.24 ± 0.05	0.42 ± 0.05	0.36 ± 0.04	0.61 ± 0.24
0.469.........	0.43 ± 0.09	*	0.53 ± 0.08	*	*
0.480.........	0.47 ± 0.07	*	0.71 ± 0.15	*	*
0.820.........	0.34 ± 0.03	0.20 ± 0.03	0.44 ± 0.05	0.28 ± 0.05	0.70 ± 0.19
0.821.........	0.45 ± 0.12	0.27 ± 0.05	0.58 ± 0.07	0.37 ± 0.07	0.70 ± 0.34
0.952.........	0.49 ± 0.13	*	0.74 ± 0.15	*	*
0.953.........	1.23 ± 0.11	*	1.49 ± 0.19	*	*

NOTE.—As in Table 4A, asterisks denote those phases where the lines could not be deblended, or were not visible (as was the case with Ca II H).

than in the primary. This is to be expected, as the greater surface gravity and density in the dwarf will result in an enhancement of lower decrement photons, as verified by Buzasi (1989).

b) Ca II *Emission*

The H line of singly ionized calcium is consistently strongly in emission, with a mean excess EW of 0.63 ± 0.04 Å in the primary. There was no modulation of the EW with phase. We cannot assert much more since this line lies in a region of both lower instrumental sensitivity and reduced stellar flux. In addition, blending with Hε made measuring the excess difficult, and in most phases, the secondary was not visible.

The data on the two available lines of the Ca II IRT (8498 Å and 8542 Å) are more reliable. There is unquestionably excess emission at all phases. There is no discernible modulation with phase, although the lines are correlated well with one another.

We observe that the secondary appears much more prominently in the IRT than it does in the Ca II H line; in fact, the only convincing appearance of emission from the secondary in Ca II H is in both phases near $\phi = 0.820$. This might seem worrisome at first, since both lines originate from the same upper atomic level, but the Ca II H line is much more optically thick than the IRT. Both lines are collision-dominated, so the IRT will respond to local conditions fairly deep in the atmosphere, while the Ca II H line will be indicative of conditions in higher regions.

c) *Lack of* He I D_3 *Emission*

Emission in the He I D_3 is indicative of flares, as observed by Tandberg-Hanssen (1967) for the Sun. Wolff and Heasley (1984) have detected this line in absorption in the RS CVn system λ Andromedae and suggest that it arises in dwarfs in plage regions. Absorption in the D_3 line was also studied by Danks and Lambert (1985), who found that it was correlated with flux in X-rays and the Ca II H and K lines. Huenemoerder and Ramsey (1987) observed emission in II Pegasi, also an RS CVn system, which they interpreted as arising from flaring activity. Since such activity is ostensibly common in RS CVns, we examined this line in SS Boo; it did not appear in any of the spectra. We have not confirmed flarelike events in SS Boo, although detection of such transient phenomena on such a modest observing schedule might be deemed fortuitous.

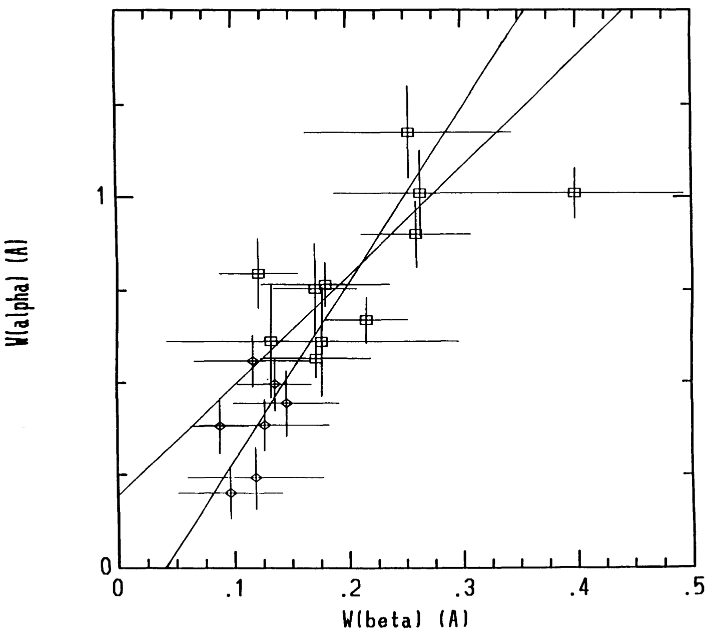

FIG. 2.—The ratio of excess emission in Hα plotted against that in Hβ. Squares correspond to derived values for the primary, diamonds to values for the secondary. The slope in energy units is actually greater for the primary once the color correction is applied. Note the nearness of the intercepts to zero, which supports our assertion that offset errors in the data are insignificant. The poorness of fit for the secondary arises from the large uncertainty in the slope; the observed slope is nevertheless consistent with the average of the $E\alpha/E\beta$ ratio.

d) The Balmer Absorption Feature

The unusual excess absorption near primary eclipse in both Balmer lines made SS Boo quite an interesting beast, especially since our phase coverage allowed us to place constraints on the origin and extent of the material causing it. We have a pair of observations around primary eclipse, one at $\phi = 0.95$, just before the primary begins to obscure the secondary, and at $\phi = 0.08$, just after the eclipse. The former pair shows the absorption; the latter does not.

We interpret the feature, which is quite apparent in Figures 1*a* and 1*b* at phases $\phi = 0.952$ and $\phi = 0.953$, as caused by material associated with the primary which is absorbing the emission and continuum from the secondary. Two reasons support this: first, there is no analogous feature near secondary eclipse, and second, the feature appears near the velocity of the secondary, which at the phases of interest will be slightly redward of the primary.

We begin our analysis by assuming that the material is spherically symmetric about the primary. The feature is much more likely a prominence-like structure, as in the eclipsing binary V471 Tau, K2 V + DA2, in which a loop on the primary occults the white dwarf just before eclipse (Guinan *et al.* 1986), but our phase coverage cannot at present constrain the feature to one hemisphere. However, an examination of the velocities of the components at $\phi = 0.952$ revealed that the center of the feature is absorbing about 20 km s^{-1} (~0.5 Å) redward of where we would expect if it had no motion of its own. The nearness of this figure to the rotation velocity derived for the primary indicates that the material is corotating with the subgiant. This is expected if the feature is indeed prominence-like.

Since there is no excess absorption in either line at the phases just beyond primary eclipse ($\phi = 0.081$, $\phi = 0.091$), and since the geometry of the system is well-established, we were able to place limits on the extent of the material. Phase $\phi = 0.952$ is just before the onset of the eclipse, when the minimum separation between the limbs of the stars in the plane of the sky is 1.65 $R_\odot$ and the separation between the leading limb of the primary and the far limb of the secondary is 1.65 $R_\odot + (2 \times R_{\rm sec}) = 4.27\ R_\odot$ (see Fig. 3). The former figure is the absolute lower limit on the extent of the material, while the latter is the largest lower limit that can be assigned with our phase coverage. The upper limit on the material's extent is the minimum separation of the stars at $\phi = 0.081$, which is 6.07 $R_\odot$. To summarize, the material extends at least 1.65 $R_\odot$ from the surface of the primary and not more than 6.07 $R_\odot$. We do not feel that more complex modeling is justified with two observations extant.

These constraints do not exclude the possibility of mass transfer from the material to the secondary. The volume radius of the Roche lobe R_L (such that the volume of the entire Roche lobe is $4/3\pi R_L^3$), obtained from Pringle and Wade (1985), is 7.89 $R_\odot$ for SS Boo. Since $R_{\rm pri} = 3.28\ R_\odot$, the shell need extend only 4.61 $R_\odot$ from the subgiant to overflow the lobe. Mass transfer may show up in the spectrum as a phase-dependent absorption feature, as noticed for the RS CVn system UX Ari by Huenemoerder, Buzasi, and Ramsey (1989). Such a feature would appear at the phase when our line of sight is along the stream flowing from the primary to the secondary; this is not apparent in any of our spectra for SS Boo. This is not surprising since the primary underfills its Roche lobe, and any loss from the extended material to the secondary would be at a very low rate. In addition, application of the stream model of Lubow and Shu (1975) indicates that the stream would be along our line of sight around $\phi = 0.95$, where the main absorption feature would mask it. As yet, therefore, there is no evidence for mass transfer in SS Boo. If the extended material is contained entirely within the primary's Roche lobe, the limits on the outer edge range from 1.65 $R_\odot$ to 4.61 $R_\odot$.

Having established the probable size of the feature, we continued our simple model to obtain an order-of-magnitude estimate on the density and mass therein. Since the absorption is occurring at a phase near but prior to eclipse, if the material extends to 4.27 $R_\odot$ from the surface of the primary, it is absorbing all of the excess emission from the secondary plus what we observe below the continuum. In Hα, we found $I/I_0 = 0.59 \pm 0.11$, and in Hβ, $I/I_0 = 0.30 \pm 0.18$. Since the continuum was normalized to one, I was simply (1 − absorption EW) and I_0 was taken as an average of (1 + emission EW) outside of eclipse. We assumed that the material is optically thin hydrogen to obtain the optical depth, which was of order unity; assuming spherical symmetry and dividing by the physical path length yielded the absorption coefficient α, in cm^{-1}, in the material. Using a radiation field temperature of $T \approx 4500$ K (since the lines in question are photoionization-dominated), we obtained the line Doppler width $\Delta\nu_{\rm D}$. From Lang (1980) we have $\alpha = 1.7 \times 10^{-2}\ \Delta\nu_{\rm D}^{-1} n_2$ for Hα, where n_2 is the population of atoms in level 2 per cubic centimeter. Inserting α and assuming a Boltzmann population distribution we can find the density of atoms in the ground state. This is $n_1 \approx n_e \approx 5 \times 10^{10}$ cm^{-3} (where we assume the gas to be half ionized in ≈10,000 K local conditions implied by the strong hydrogen lines) which is slightly lower than that expected in prominences. However, a two-solar-radius spherical cloud of this density is highly unlikely, and if the material is a large

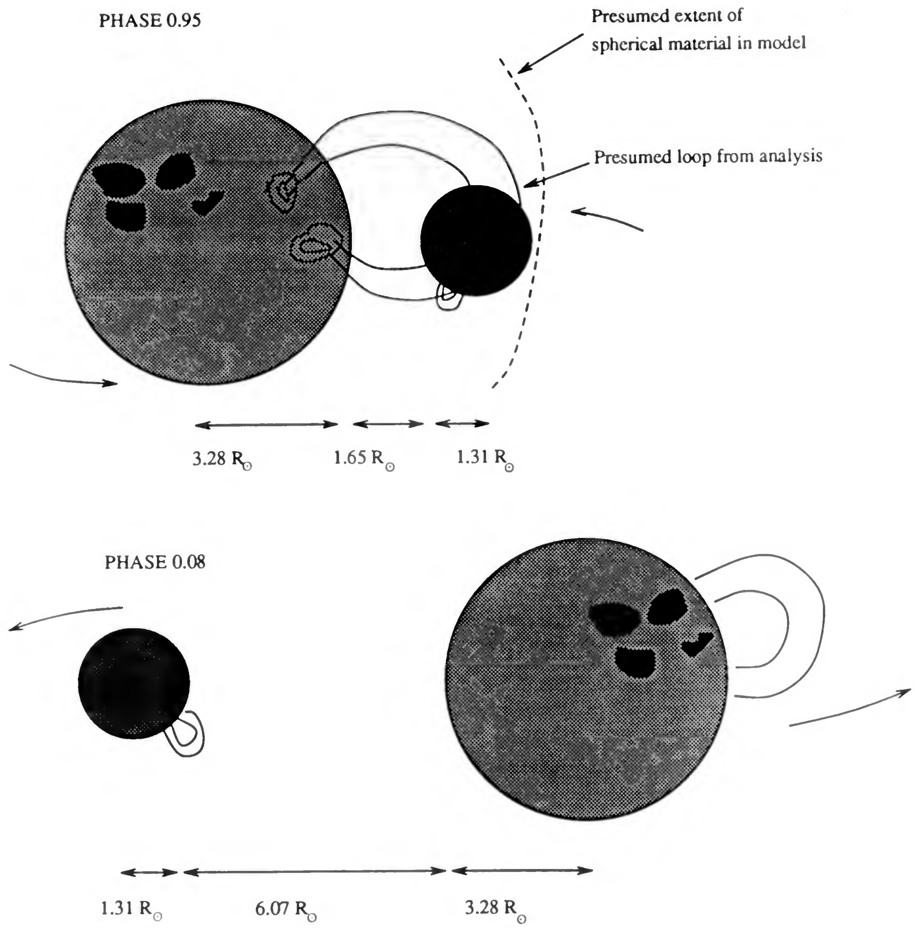

FIG. 3.—The geometry of SS Boo in the plane of the sky at both phases observed near primary eclipse. The lower limit of 1.65 $R_\odot$ is apparent in the upper figure. The absence of the feature in the lower figure determines the upper limit of 6.07 $R_\odot$. We take an intermediate value $R_{tot} = 1.65\ R_\odot + 2.62\ R_\odot$, at which the extended material just covers the secondary at the near-eclipse phase, for our calculations.

prominence-like feature as we expect, the shorter path length required in the above calculation would give a higher estimate of the density. This argument by no means proves conclusively that we are seeing a prominence; nor does it give a density with more accuracy than an order of magnitude or so, but it does indicate that SS Boo likely has a large localized extended structure.

We note in conclusion that we have assumed a covering factor of 100%, that is, that at the phase observed the material completely covers the disk of the secondary. If in fact it is less extensive, our figures will be artificially low by some covering factor describing the fraction of the secondary's disk that is obscured.

IV. CONCLUSION

Our observations of SS Boo have revealed the expected excesses in emission in the Balmer lines and Ca II H line and IRT. The emission does not appear to modulate with phase in any of these lines, so either it must arise from global phenomena or our relative paucity of observations conceals it.

Of special interest was an absorption feature near primary eclipse attributed to the presence of material around the primary which obscured all of the excess and some of the continuum from the primary. The system geometry indicates that the material probably extends at least about 4 $R_\odot$, and not more than about 4.6 $R_\odot$ from the primary. No evidence of mass transfer is evident, but it is unlikely we would have resolved it with our current observations. The density in the material was estimated to be about 5×10^{10} cm^{-3}. Our phase coverage is inadequate, however, to make any but the crudest guesses regarding the peculiarities of the system, and we plan more extensive observations of the eclipse in the X-ray, the UV, and the optical in the coming season.

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