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ON THE SPECTRA OF STARS OF CLASS III *b*.

By N. C. DUNÉR.

IN the beginning of the year 1893 the Upsala Observatory came into possession of a new double refractor, provided with a Steinheil visual objective of 36 cm aperture and a photographic objective, also by Steinheil, of 33 cm aperture. The mounting is a very perfect one by Repsold. From the first I had planned to reëxamine the stars of the III class. On the one hand it was to be expected that with this instrument, the light-gathering power of which is considerably greater than that of the Lund refractor, more details would be visible in the spectra; while on the other hand, eight years had already passed since the publication of my memoir, "Sur les étoiles à spectres de la troisième classe," during which time many new stars belonging to class III had been discovered, and it seemed to me desirable that so far as possible all such stars in the northern heavens should be examined by one and the same observer. In this investigation, as well as in all other work with the refractor, serious interruptions occurred, partly because the summer nights here are as light as day, partly on account of the almost invariably bad and unfavorable weather of Upsala winters, and partly also because

of other causes, one of which, my rather poor health during recent winters, has unfortunately had an ever increasing effect. As a consequence this investigation, while well advanced in several hours of right ascension, still contains serious omissions in hours 2–8, 16–18 and 20.

Furthermore, since the greatest telescopes in the world have entered this field, it can hardly be of further interest to continue these investigations in a climate so unsuitable as that of Upsala for astronomical observations. But since in the course of the observations already made certain new details have been discovered in the spectra of stars of class III *b*, and since these confirm the results published by Professor Hale in the *ASTROPHYSICAL JOURNAL*, Vol. VIII, No. 4, I beg leave to present them here.

Four spectroscopes, all of the Zöllner type, have been employed in my observations. The first three belong to a set made by O. Toepfer, of Potsdam, and the direct-vision prisms have the following dispersions (C — G):

I	3° 23'
II	5° 1'
III	6° 56'

Spectroscope IV was made after my own indications by G. Rose, of Upsala, and contains a Steinheil direct-vision prism giving a dispersion of 10° between the same limits. These spectroscopes can be attached to the lowest eyepiece of the refractor, and in good atmospheric conditions give very beautiful spectra. For the greater part of the spectra of type III *b* the spectroscope designated as Ss III was found to be best adapted; for very faint objects Ss I was most suitable. For the most brilliant spectra Ss IV occasionally performed admirably.

As for the designations of the stars I need only remark that by “Birm.” is meant the *second* edition, published by Espin, of Birmingham’s Catalogue of Red Stars. The colors of the stars, the spectra, and the spectral bands, are designated in exactly the same manner as in my memoir “Sur les étoiles à spectres de la troisième classe.”

An examination of the following list of my observations of spectra of type III *b* will show that my hopes of seeing more with the Upsala refractor than with the Lund refractor were not disappointed. Of first importance is the fact that I was able to detect without difficulty bright lines in various spectra, which at Lund were either invisible or at least could not be discovered. But it has also been possible for me here to determine with far greater ease and certainty the nature of several other spectra, among which mention may be made of the extremely interesting objects 280 *Schj.* and R S Cygni.

$$3 \text{ SCHJ.} = 4 \text{ BIRM.} = \text{BD.} + 43^{\circ}53 \text{ (8.2}^{\text{m}}\text{)}.$$

Rrg = 9.0. Sp. III *b*!! 3 bright zones, the blue one extremely faint and hardly visible. Band 6 strong. The yellow subzone bright, bands 4 and 5 well seen. Bands 2 and 3 suspected on one occasion. (Ss I 93.9.18, 93.10.5, 93.10.29, 92.10.30, 93.10.31, 93.11.3, 97.11.1. Ss III 95.9.27, 95.10.11, 97.11.1.)

$$10 \text{ BIRM.} = \text{BD.} + 34^{\circ}56 \text{ (8.1}^{\text{m}}\text{)}.$$

Rrg = 8.2. Sp. III *b*!! 3 bright zones, the blue one not particularly faint. The yellow subzone is well marked. Bands 6 and 9 are broad and very strong, 5 fairly strong, 4 clearly visible, 3 rather faint, 2 very faint. (Ss I 93.10.15, 93.10.30, 93.10.31, 93.11.5. Ss III 95.10.11, 95.10.24, 96.9.29, 96.10.6.)

$$13 \text{ BIRM.} = \text{W CASSIOPEIAE (VAR.)}.$$

Rrg = 8.8. Sp. III *b* with 2 zones. Band 6 broad. (Ss I 93.10.15, 93.10.30, 93.10.31, 93.11.5, 95.10.24, 95.11.15. Ss III 95.10.24, 95.11.15.)

$$7 \text{ SCHJ.} = 19 \text{ BIRM.} = \text{BD.} + 25^{\circ}205 \text{ (7.1}^{\text{m}}\text{)}.$$

Rrg = 8.0. Sp. III *b*!!! 4 zones, of which the ultra-blue is rather faint. Bands 9 and 10 strong and broad, 6 narrow, not brighter than 4; 4 is rather broad, clearly visible, and sharply bounded. Band 5 is fainter than 4, but broad, dim; 2, 3, 8 are faint. (Ss I 93.10.15, 93.10.22, 93.10.30, 93.10.31, 93.11.5.)

Ss III 95.9.27, 95.10.11, 95.10.24, 96.1.5, 96.1.11. Ss IV 96.9.18.)

$$29 \text{ BIRM.} = \text{BD.} + 57^{\circ}325 \text{ (9.2}^{\text{m}}\text{)}.$$

Rrrg = 8.9. Sp. III *b*! The spectrum is extremely faint with 2 zones. Band 6 broad and dark. (Ss I 93.10.30, 95.11.15, 96.10.11. Ss III 95.11.15, 96.1.11.)

X CASSIOPEIAE (VAR.).

Rrrg = 9.1. Sp. III *b*. 2 zones. Band 6 broad, strong. (Ss I 93.11.5, 95.10.24, 96.9.29. Ss III 95.10.24, 96.9.29.)

$$42 \text{ BIRM.} = \text{BD.} + 51^{\circ}575 \text{ (9.0}^{\text{m}}\text{)}.$$

Rrrg = 9.0. Sp. III *b*! 2 zones. Band 6 very broad and dark. (Ss I 95.10.11. Ss III 95.10.11.)

$$64 \text{ BIRM.} = \text{BD.} + 57^{\circ}702 \text{ (7.9}^{\text{m}}\text{)}.$$

Rrg = 8.1. Sp. III *b*!!! 4 zones, 3 of which are very bright, while the ultra-blue one is quite faint. The principal bands extremely broad and black, 5 rather strong, 4 clearly visible, 3 and particularly 2, faint. (Ss I 93.10.30, 93.10.31, 93.11.8, 94.2.3, 96.1.11, 96.1.20. Ss III 93.12.1, 95.11.15, 96.1.11, 96.1.20, 96.1.26.)

$$66 \text{ BIRM.} = \text{BD.} + 47^{\circ}783 \text{ (9.0}^{\text{m}}\text{)}.$$

Rrg = 8.6. Sp. III *b*! 3 zones, of which the green is the brightest. Bands broad but dim. (Ss I 93.10.31, 93.11.8, 94.2.3, 96.1.5. Ss III 96.1.5.)

27a SCHJ. = 75 BIRM. = U CAMELOPARDI (VAR.).

Rrg = 8.7. Sp. III *b*!! 3 zones, the blue one very faint. Band 9 very broad and strong, 6 fainter, 4 and 5 rather strong, 3 and particularly 2, faint. (Ss I 93.10.22, 93.10.31, 93.11.8, 95.10.24. Ss III 95.10.24.)

$$81 \text{ BIRM.} = \text{BD.} + 61^{\circ}667 \text{ (7.0}^{\text{m}}\text{)}.$$

Rrg = 7.8. Sp. III *b*!! 4 zones, the ultra-blue one quite faint. Bands 9 and 10 very strong and broad, 6 fainter. The yellow subzone not strong. Band 5 is broad, 4 clearly visible, 2 and 3 faint. (Ss I 93.10.31, 93.12.28.)

41 SCHJ.= 97 BIRM.= $67^{\circ}350$ (7.0^m).

Rrg=8.8. Sp. III *b*!!! 4 zones, the ultra-blue one faint. The yellow subzone very bright, particularly in the less refrangible half. Bands 9, 10 and 6 very broad and strong, 5 broad and strong, 4 rather strong, 8 clearly visible, 2, 3, 7 faint. (Ss I 93.4.23, 93.12.28. Ss III 93.12.28.)

45 SCHJ.= 105 BIRM.= 5 W ORIONIS (VAR.).

Rrg=8.8. Sp. III *b*!!! 3 zones, the blue one rather faint. On November 19, 1895, I thought I detected a very faint trace of an ultra-blue zone. The yellow subzone is very bright. Band 9 very strong, 6 strong, and contains a *bright* line. Band 5 strong, apparently double, 4 and 3 rather strong, 2, 8 rather faint. (Ss I 93.11.23, 95.11.19, 96.1.26. Ss III 96.1.26.)

BD.+ $38^{\circ}1035$ (8.5^m).

Rrg=8.2. Sp. III *b*!! 3 zones, the green one the brightest, the blue one somewhat faint. On one occasion the yellow subzone was seen conspicuously. Bands 9 and 6 are strong. Espin's star BD.= $+38^{\circ}1038$ is undoubtedly identical with this one. (Ss I, Ss. III 94.2.22, 95.10.24, 96.1.6, 96.1.11.)

BIRM. 125 = BD.+ $35^{\circ}1046$ (8.9^m).

Rrg=8.2. Sp. III *b*! 3 zones. Band 9 strong, 6 rather dull. (Ss I, Ss III 96.1.9, 96.1.11.)

72 SCHJ.= 172 BIRM.= BD.+ $26^{\circ}1117$ (7.4^m).

Rrg=8.3. Sp. III *b*!!! 3 zones and perhaps also an ultra-blue one. Band 9 very strong, 6 not strong. Bands 5, 4 quite strong, 3 well seen, 2 faint. (Ss I, Ss III 94.2.3, 97.2.10.)

74 SCHJ.= 187 BIRM.= BD.+ $14^{\circ}1283$ (6.5^m).

Rrg=8.3. Sp. III *b*!!! 4 zones, the ultra-blue one quite faint. Bands 9 and 10 strong, broad, 6 remarkably faint, fainter than 5. 4 stronger than 5; 3, 2 well seen. (Ss I, Ss III 93.11.23, 94.2.3.)

$$78 \text{ SCHJ.} = 192 \text{ BIRM.} = \text{BD.} + 38^\circ 1539 \text{ (6.3}^{\text{m}}\text{)}.$$

Rrg = 8.0. Sp. III *b!!!!* 4 zones, all of them bright; the yellow subzone extraordinarily bright. Bands 9, 10 extremely strong and broad, 6 is fainter, but strong; in this band is a hair-like, clearly visible, *bright* line. Band 5 is double; the less refrangible component is the fainter. Band 4 is broad, strong and sharply bounded, 1 quite broad and distinct, 2 rather broad and strong, 3 narrow, but rather dark. The distance from 2 to 3 is greater than that from 3 to 4, but 2 is shaded toward the violet, so that 3 is in the middle of the red subzone; 7, 8 are easily seen and between them there is a faint line. (Ss I 93.11.23, 94.2.2, 94.2.3. Ss II 93.3.1, 93.11.23, 94.2.3. Ss III 93.11.23, 94.1.4, 94.2.2, 94.2.3, 95.3.18, 96.1.9, 96.1.11, 97.2.10. Ss IV 97.2.23, 97.2.24.)

$$\text{BD.} + 31^\circ 1388 \text{ (8.1}^{\text{m}}\text{)}.$$

Rrg = 8.0. Sp. III *b!!* 3 zones, all of them bright. Bands 9 and 6 very dark. The yellow subzone rather bright. Bands 4 and 5 suspected on one occasion. (Ss I, Ss III 96.1.23.)

$$225 \text{ BIRM.} = \text{BD.} + 25^\circ 1641 \text{ (9.0}^{\text{m}}\text{)}.$$

Rrg = 7.8. Sp. III *b!!* 3 zones, all of them bright, and perhaps an exceedingly faint trace of an ultra-violet zone. The yellow subzone is not especially bright; the extreme end of the green zone, on the contrary, is very exceptionally bright. Bands 9 and 6 are very broad and strong; 5, 4, 8 occasionally visible. (Ss I 94.2.3, 94.2.5, 96.1.23. Ss II 94.2.5. Ss III 94.2.3, 94.2.5, 96.1.23.)

$$235 \text{ BIRM.} = \text{BD.} + 24^\circ 1686 \text{ (8.2}^{\text{m}}\text{)}.$$

Rg = 7.3. Sp. III *b!!* with 4 zones, the ultra-blue one remarkably faint and hardly visible, while the blue one is very bright. Band 9 is quite strong; 6, on the contrary, is very faint. The yellow subzone is no brighter than the rest of the spectrum. (Ss I, Ss III 96.1.20, 96.1.23, 97.2.28.)

264a BIRM. = BD. + 3° 1958 (8.3^m).

Rrg = 8.3. Sp. III *b!!* with two bright and one extremely faint blue zone. Band 6 is broad and strong. (Ss I, Ss III 94.2.5, 97.2.28.)

115 SCHJ. = 211 BIRM. = BD. + 17° 1973 (6.5^m).

Rrg = 8.7 Sp. III *b!!!!* with 4 zones, the ultra-blue one faint. Bands 9 and 10 are exceedingly broad and dark, 6 somewhat narrower and fainter, with *bright* lines. The yellow subzone is very bright. Band 5 strong, double, 4 rather strong, 3 well seen, 8, 2 faint. (Ss I 94.2.3, 94.2.5, 94.3.24, 96.3.20. Ss II 94.2.3. Ss III 94.2.3, 94.2.5, 94.3.24, 96.3.20, 96.4.2, 97.2.24.)

318 BIRM. = BD. + 68° 617 (6.2^m).

Rrg = 8.2. Sp. III *b!!!!* 4 zones, the ultra-blue one quite bright. Bands 9 and 10 exceedingly broad and dark. 6 is relatively faint but contains *bright* lines. 5 is broad, strong and distinctly double, 4 strong, 3 sharply terminated, not faint, 2 relatively strong, 1, 7 faint, 8 well seen. On one occasion a band was suspected far out in the ultra-blue zone. (Ss I 94.3.22. Ss II 93.4.1, 96.4.4. Ss III 94.3.22, 94.3.25, 95.4.14, 96.3.30, 96.4.2, 96.4.4.)

145 SCHJ. = 350 BIRM. = BD. + 1° 2694 (8.1^m).

Rrg = 8.8. Sp. III *b!!* 3 zones, the blue one not especially faint. The yellow subzone exceptionally faint. Bands 9, 6 strong, 5 rather strong, 4 easily visible, 3 and perhaps also 2 faintly visible. (Ss I, Ss III 94.3.25, 95.4.15, 95.4.17, 95.4.26, 95.5.1. Ss II 95.5.1.)

152 SCHJ. = 364 BIRM. = BD. + 46° 1817 (5.5^m).

Rrg = 8.2. Sp. III *b!!!!* Remarkably beautiful, with 3 very bright and one rather faint ultra-blue zone. The more refrangible half of the yellow subzone is very bright, while the less refrangible half appears veiled. The principal bands, 9, 10 and 6 are exceedingly broad and strong; in 6 near the yellow sub-

zone there is a fine, brilliant *bright* line. Band 5 consists of two rather broad components, the more refrangible of which falls in the middle of the subzone. Half-way between this and band 6 is a fine, rather faint line. Band 8 is rather strong, 4 quite strong, 3 somewhat stronger than 4; 7 and 2 are faint. (Ss I 95.4.14. Ss II 95.4.14. Ss III 94.3.25, 95.4.14, 95.4.15, 95.4.30, 95.5.1, 95.5.2, 95.5.4, 96.4.2. Ss III 97.2.28, 97.4.26.)

155*b* SCHJ. = 374 BIRM. = BD. 66° 780 (7.5^m).

Rrg = 8.4. Sp. III *b!!!* 4 zones, the ultra-blue one very faint. Bands 9 and 6 are very strong, 5 strong, not certainly double, 4 faint, 3 stronger. Between 5 and 6 a line. The spectrum in general resembles that of 152 *Schj*. On one occasion several bands were suspected in the blue zone; this zone also appears to terminate in a bright line. (Ss I 95.5.4. Ss III 95.5.4, 97.4.26. Ss IV 97.4.26.)

BD. + 38° 2389 (8.0^m).

Rg = 7.5. Sp. III *b!!* 3 zones and perhaps a faint trace of the ultra-violet one. The yellow subzone bright; bands 9 and 6, especially the latter, very strong. (Ss I, Ss III 97.4.26.)

182 SCHJ. = 439 BIRM. = V CORONAE (VAR.).

Rgj = 8.5. Sp. III *b*. 3 zones, the blue one faint. Band 9 strong, band 6 very dim; no other details. (Ss I, Ss III 95.4.30, 95.5.2, 97.4.26.)

545 BIRM. = BD. + 36° 3168 = T LYRAE (VAR.).

Rrrg = 9.1. Sp. III *b!!* 2 bright and a hardly visible blue zone. The yellow subzone very bright. Band 6 very strong, 5 and 4 rather strong, 3 quite faint. 2 was also suspected on one occasion. (Ss I, Ss III 95.8.16, 95.8.18, 95.8.25, 96.8.14, 96.9.1.)

561 BIRM. = BD. + 36° 3243 (7.5^m).

Rrg = 8.2. Sp. III *b!!* 3 zones, the blue one bright. The yellow subzone is not especially bright. Band 9 is very broad

and strong, 6 broad and strong, 5 rather strong, 4, 3 well seen, 2 very faint. (Ss I, Ss III 95.8.16, 95.8.18, 95.8.25, 96.8.13, 97.8.24).

229 SCHJ. = 607 BIRM. = BD. + 76°734 (6.5^m).

Rrg = 8.5. Sp. III *b!!!!* 4 zones, the ultra-blue one not especially faint. Bands 9, 10 very broad and dark. 4 is rather broad and very dark, after 9 and 10 the strongest detail in the spectrum, 5 broad, grayish, perhaps double, 6 rather broad but dim, 2, 3, and 8 well seen, 7 rather faint. (Ss I 93.8.6, 93.10.29, 95.9.3, 95.9.25. Ss II 93.10.29. Ss III 95.9.3, 95.9.25, 95.9.26, 96.8.13. Ss IV 96.8.13.)

608 BIRM. = BD. + 45°2906 (8.6^m).

Rrg = 8.6. Sp. III *b!!* 3 zones, the blue one very faint. The yellow subzone rather bright. Bands 9 and 6 very strong, 5 well seen, 4 faint. (Ss I 93.8.6, 95.9.9, 95.9.22. Ss III 95.9.9, 95.9.22.)

616 BIRM. = BD. + 32°3522 (8.0^m).

Rrg = 8.3. Sp. III *b!!!!* 4 zones, the blue one bright, the ultra-blue one very faint. Bands 9, 10, 6 are exceedingly broad and strong, 5 strong, 3, 4 well seen, 4 stronger than 3. Bands 8 and 2 hardly seen with certainty. (Ss I 93.8.7, 95.8.15, 95.8.16, 95.9.22, 95.9.23. Ss III 95.8.15, 95.8.16, 95.9.22, 95.9.23.)

BD. + 85°332 (9.2^m).

Rg (peculiar color) = 6.8 Sp. III *b!!* 3 zones, the green one brightest, the blue not faint. Band 9 strong and broad, 6 rather faint. Band 4 suspected on one occasion. (Ss I, Ss III 96.8.14, 96.8.31, 96.9.9.)

627*a* BIRM. (9.5^m).

Rrg = 8.0. Sp. III *b!* 3 zones. Bands 6 and 9 rather strong. (Ss I, Ss III 95.8.16, 96.8.31, 96.9.29.)

639*a* BIRM. = BD. + 20°4394 (9.4^m).

Rrg = 8.0. Sp. III *b!!* 3 zones, all of them bright. The

yellow subzone not very bright. Bands 9 and 6, particularly 9, are very broad and dark. Star brighter than the 9th magnitude. (Ss I, Ss III 96.9.9, 96.10.2.)

$$643 \text{ BIRM.} = \text{BD.} + 20^{\circ}4417 \text{ (8.9}^{\text{m}}\text{)}.$$

Rrg = 8.0. Sp. III *b!!* 3 zones, the blue one rather faint. Bands 9 and 6 are very strong, 8 perhaps visible; otherwise no details. (Ss I, Ss III 97.8.30.)

$$650 \text{ BIRM.} = \text{BD.} + 47^{\circ}3031 \text{ (8.0}^{\text{m}}\text{)}.$$

Rrg = 8.4. Sp. III *b!* 3 zones, the green one very bright, the blue one somewhat faint. The yellow subzone rather bright. Bands 9 and 6 are strong. (Ss I, Ss III 95.8.6, 95.8.18, 95.8.25, 96.9.1.)

$$651 \text{ BIRM.} = \text{BD.} + 35^{\circ}4002 \text{ (9.5}^{\text{m}}\text{)}.$$

Rrg = 8.3. Sp. III *b!!* 3 zones, the green one very bright, and also the blue one bright. Bands 9 and 6 exceedingly broad and dark. (Ss I 93.10.3, 93.10.29, 95.8.16, 96.8.12, 96.8.13. Ss III 95.8.16, 96.8.12, 96.8.13.)

$$657 \text{ BIRM.} = \text{BD.} + 38^{\circ}3957 = \text{R S CYGNI (VAR.)}.$$

Rrg = 8.5. Sp. III *b!* 3 zones; the yellow and red subzones rather bright. Bands 9 and 4 very well developed; 5 and more especially 6 are faint, 2 and 3 exceedingly faint. (Ss I 93.9.21, 93.10.13, 93.10.22, 95.8.25, 95.8.28. Ss III 95.8.25, 95.8.28.)

$$659a \text{ BIRM.}$$

Rrg = 8.2. Sp. III *b!* 3 zones, the blue one very faint. Band 9 extraordinarily broad and strong, 6 broad and strong. (Ss I, Ss III 95.8.28, 95.9.9.)

$$662a \text{ BIRM.} = \text{BD.} + 37^{\circ}3876 \text{ (9.5}^{\text{m}}\text{)}.$$

Rrg = 8.6. Sp. III *b!* 3 zones, the green one the brightest. Bands 9 and 6 are broad and quite dark. (Ss I 93.8.7, 95.9.17, 95.9.23, 96.10.6. Ss III 95.8.18, 95.9.17, 95.9.23, 96.10.6.)

665 BIRM. = BD. + 37°3903 (9.4^m).

Rrg = 8.7. Sp. III *b*. 2 or possibly 3 zones. The bands are broad but dim. (Ss I 93.8.7, 95.9.27. Ss III 95.9.27, 96.11.1.)

681 BIRM. = V CYGNI (VAR.).

Rrrg = 9.5. Sp. III *b!!* 2 bright zones; band 6 broad. (Ss I, Ss III, 97.9.3.)

BD. + 32°3954 (9.4^m).

Rrg = 8.8. Sp. III *b!!* 3 zones, the green one the brightest, the blue one somewhat faint. Bands 9 and 6 are strong and broad. (Ss I, Ss III 95.10.15, 96.9.15, 96.10.6.)

248 *b* SCHJ. = 705 BIRM (9.5^m).

Rrg = 8.3. Sp. III *b!* 3 zones, the green one the brightest, the blue one rather faint. Bands 9 and 6 are strong and broad. (Ss I 93.8.23, 93.10.30, 95.8.16. Ss III 95.8.16.)

250 SCHJ. = 710 BIRM. = S CEPHEI (VAR.).

Rrrg = 9.4. Sp. III *b!!* 2 bright zones and a hardly visible blue one. The yellow subzone is not especially bright, but bands 4 and 5 are visible. Band 6 is rather strong. (Ss I, Ss III 95.12.9, 97.4.26, 97.9.3.)

249 *a* SCHJ. = 711 BIRM. = BD. + 34°4500 (6.2^m).

Rrg = 8.4. Sp. III *b!!!!* 4 zones; three of them very bright, the ultra-blue one somewhat faint. The yellow subzone is brilliant. Bands 9 and 10 are very broad and strong, 6 considerably fainter; near its head, toward the yellow subzone, a narrow, faint, *bright* line. Band 5 is clearly double; the more refrangible component is stronger than the other. 4 is not so broad as 5, but at least as strong. Between 5 and 6 a very narrow and faint line. 8 and 7 are clearly visible, 2 somewhat stronger than 3; both rather faint, 1 faint. (Ss I 93.8.6, 93.8.23, 93.10.23, 93.10.30, 93.11.5, 93.11.23. Ss II 93.11.5, 93.11.23. Ss III 93.11.23, 93.11.26, 93.11.28, 95.9.1. Ss IV 96.8.2, 96.8.12, 96.8.14, 96.9.6, 96.9.9, 96.9.20, 97.8.24.)

251 SCHJ. = 713 BIRM. = R V CYGNI (VAR.).

Rrrg = 9.2. Sp. III *b!!* 3 zones, the blue one very faint. The yellow subzone rather bright. Band 6 is broad and strong, 5 well seen, 4 fainter than 5, 2 and 3 exceedingly faint. (Ss I 93.8.6, 93.8.23, 93.10.23, 93.11.7. Ss III, 95.9.9, 96.9.6. Ss IV 96.8.14, 96.9.6.)

257 SCHJ. = 720 BIRM. = BD. + 49°3673 (9.1^m).

Rrrg = 8.9. Sp. III *b!!* 2 bright zones and a hardly visible blue one. The yellow subzone bright. Band 6 is extraordinarily broad and dark. Bands 4 and 5 not certainly visible. (Ss I 93.8.6, 95.11.19, 96.9.1, 97.9.3. Ss III 95.9.19, 96.9.1, 97.9.3.)

19 PISC. = 273 SCHJ. = 756 BIRM. = BD. + 2°4709 (6.2^m).

Rrg = 8.5. Sp. III *b!!!!* 4 zones, the ultra-blue one not especially faint. The yellow subzone is very bright. Bands 9 and 10 are very broad and dark. 6 consists, beginning at the yellow, of (1) a rather strong and broad dark line; (2) a *bright* line; (3) a very faint shading. This whole band is remarkably faint. 4 is sharp, broad and dark, 5 very distinctly double, composed of two not strong lines. 3 is narrow but rather dark, even darker than one of the components of 5. 2 is dim but broad, 1 faint, 8 well seen, 7 faint. Between 5 and 6 a narrow faint line was seen on one occasion. (Ss I 93.10.15, 93.10.30, 93.10.31, 93.11.23. Ss III 93.11.23. Ss IV 96.8.13, 96.9.6, 96.9.9, 96.9.18, 96.9.20, 96.12.3.)

280 SCHJ. = 764 BIRM. = BD. + 59°2810 (7.8^m).

Rrg = 8.4. Sp. III *b!!!!* *Unique*, not because of the strength of the chief bands, for these are faint. Band 9 is fairly conspicuous, but not very broad, 10 much fainter, and 6 fainter than all the other bands. On account of the slight strength of the chief bands, the intensity of the spectrum gradually falls off towards the blue, so that the ultra-blue finally becomes exceedingly faint. Band 4 is as broad as half the yellow sub-

zone, quite black, and the most conspicuous detail in the whole spectrum. 2 is as strong as 9, or even stronger, broad and sharply terminated; 5 is easily visible, 3 narrow and faint. (Ss I 93.9.23, 93.10.11, 93.10.15, 93.10.23, 93.10.29, 93.10.30, 93.10.31, 93.12.2. Ss III 93.11.23, 93.12.2, 95.9.9, 95.9.17, 95.12.9, 96.9.9. Ss IV 96.8.12, 96.9.6, 96.9.9.)

$$765 \text{ BIRM.} = \text{BD.} + 42^{\circ}48'24'' (9.4^{\text{m}}).$$

Rrg = 8.0. Sp. III *b* !! 4 zones, the ultra-blue one exceedingly faint. Band 9 is very strong and broad, 6 only a little fainter. The yellow subzone is rather bright; bands 4 and 5, particularly the latter, visible but faint. (Ss I 93.10.5, 93.10.30, 93.10.31. Ss III 95.9.9.)

It appears in the first place from these observations that in spectra of all bright stars of class III *b*, namely W Orionis (6.0^{m}), 78 *Schj.* (6.3^{m}), 115 *Schj.* (6.5^{m}), 318 *Birm.* (6.2^{m}), 152 *Schj.* (5.5^{m}), 229 *Schj.* (6.5^{m}), 249 *a Schj.* (6.2^{m}), and 19 Piscium (6.2^{m}) band 5 is double, and in band 6 near the less refrangible edge there is a bright line, while these details cannot be made out with certainty in the spectra of the only slightly fainter stars 7 *Schj.* (7.0^{m}), 41 *Schj.* (7.0^{m}), 74 *Schj.* (6.5^{m}), and 155 *b Schj.* (7.3^{m}). In some of the latter spectra band 5 is nevertheless very broad. It must consequently be regarded as highly probable that both of these details are common to all spectra of type III *b*. They are, moreover, clearly visible in Professor Hale's photograph of the spectrum 152 *Schj.*

In a closer comparison of the spectra of different stars one is struck by the very marked differences of the relative strength of certain bands. This is particularly the case with bands 6 and 4. For example, in the spectrum of 152 *Schj.* band 6 is almost as strong as band 9, and is consequently one of the most striking details of the spectrum, while band 4 is quite faint. On the other hand, in the very remarkable spectrum of 280 *Schj.*, 4 is the strongest and 6 the faintest visible band in the whole spectrum, in fact fainter than bands 2-5 and 9 and 10. Of the

remaining stars of this class, some, considered with reference to the relative intensities of bands 4 and 6, resemble 152 *Schj.*, while others are more like 280 *Schj.*; but so far as my experience goes the great strength in the spectrum of this star of band 4, combined with the remarkable faintness of band 6, is met with in the same degree in no other spectrum.

Of the spectra belonging to type III *b*, those of RS Cygni, 19 Piscium, 7 *Schj.*, 74 *Schj.*, 235 *Birm.*, 229 *Schj.*, BD.+ 85°332, and 249a *Schj.*, although, as has been said, having band 6 relatively stronger, resemble that of 280 *Schj.*; the spectra of 64 *Birm.*, 41 *Schj.*, 155b *Schj.*, 608 *Birm.*, 616 *Birm.* correspond more closely with that of 152 *Schj.*; and those of other stars, for example W Orionis, 78 *Schj.*, 115 *Schj.*, 72 *Schj.*, 64a *Schj.*, 643 *Birm.*, 634 *Birm.*, 318 *Birm.*, etc., occupy an intermediate position.

To base upon these differences in the relative intensities of these bands a division of class III *b* into subclasses, would, in my opinion, hardly be advisable. The various classes, particularly if one does not represent an evolutionary step beyond that which immediately precedes it, must show *fundamental* differences, and the relative intensities of the lines are not to be regarded as such. Moreover, one might easily get as many subdivisions as there are stars. On the other hand, as Professor Hale remarks, it should be possible to arrange these stars in a series. I shall make no investigations in this direction, since Professor Hale is engaged on this very problem, and neither the refractor nor the atmospheric conditions at Upsala can be compared with those at the Yerkes Observatory.

UPSALA,
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