DISCOVERY OF NEW BRIGHT PECULIAR STARS OF THE NORTHERN SKY

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ABSTRACT

I am now engaged in an objective-prism program directed toward the discovery of new peculiar and interesting stars in most of the northern sky. The plates utilized are 20-min. blue exposures taken with the Warner & Swasey Observatory's Burrell Schmidt telescope, now located on Kitt Peak. The dispersion of the spectra is 108 A/mm at Hγ, the limiting magnitude about m_{pg} = 10.5, and the plate quality generally excellent. This paper discusses the history and status of the project and gives examples of the variety of objects being found.

When the 24-36-inch Curtis Schmidt was transferred from its Michigan site to the far better skies of Cerro Tololo in 1966, it was agreed that the University of Michigan would have one-third of the time of the telescope. Since we were not used to having so much clear sky available, this necessitated consideration of the question of exactly what to do with the telescope. Luckily, shortly before this I had had occasion to inspect a number of the blue-region plates taken with the telescope's combined 4^{o} and 6^{o} prisms--dispersion 108 A/mm at Hγ--and had been extremely impressed (Bidelman 1966). I had even gone so far as to suggest that "such a large project as the reclassification of the stars of the Henry Draper Catalogue appears to be quite feasible and highly desirable.." (After all, Curtis' initials were H.D.!). So it did not require much effort for me to decide that the major work of the telescope would be a southern hemisphere all-sky survey, and, with the aid of the National Science Foundation and especially my associate Darrell J. MacConnell, this in fact was the case for a considerable number of years.

Even though I was on record as having thought it "feasible" to reclassify all of the Henry Draper Catalogue stars, I myself had no intention of doing this, nor had Dr. MacConnell. But what we did do, to begin utilization of the beautiful plates that kept coming, was to start a so-called "early-result" program in which we, assisted by several gifted

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graduate students, scanned the plates for all peculiar stars, supergiants and late-type dwarfs. The previously unrecognized objects were then published. The results of this work appeared in the papers by Bidelman and MacConnell (1973) and MacConnell and Bidelman (1976), in a number of short reports, and in papers by MacConnell, Frye, and Upgren (1972), and Upgren, Grossenbacher, Penhallow, MacConnell, and Frye (1972). Two later papers of similar nature, from inspection of southern plates taken subsequent to the original program, are by Bidelman (1981) and Bidelman and MacConnell (1982).

I left Michigan in the fall of 1969, to come to C.W.R.U. a year later, Quite unbeknownst to me, Dr. Nancy Houk, who had heard me talk about this project when a graduate student at Case, was greatly interested in actually carrying out the "grand design" of reclassifying the HD stars, and eventually persuaded the U. of Michigan to give her access to all of the plates taken at Cerro Tololo. The results of this happy circumstance are almost unbelievable: she has by now published MK classifications for some 94,000 stars south of $\delta = -26^{\circ}$. She is presently working on the zone from $\delta = -26^{\circ}$ to -12°, which she will finish sometime in 1985. In view of her far more extensive experience and greater use of spectral standards, her classifications for stars noted in the "early-result" program should in general clearly supersede the earlier results, though there are some cases in which the classifications were done on different plates (she is using shorter exposures for the brighter stars).

With the move of the Warner & Swasey Observatory's Burrell Schmidt to its Kitt Peak Station in June 1979 and with the acquisition of a new single 10° prism for it, it became practicable to extend the all-sky survey to the northern sky, and fortunately Dr. Houk has expressed her willingness to continue her classifications to $\delta = +90^{\circ}$. The new prism gives spectra of exactly the same dispersion as the southern plates; the only difference is a substantially greater extension of the northern spectra to the ultraviolet. To allow for this, new plates of spectral standards are being obtained, and some fields will be classified using plates taken with both telescopes. We are responsible for obtaining the plates with the Burrell; they are being taken by Resident Observer Rik Hill. The status of the project is as follows: all plate-taking from Cerro Tololo has now ceased, after the entire southern sky has been covered and even quite a number of plates have been taken as far north as $\delta = +35^{\circ}$. The total number of plates to be taken with the Burrell is 679 20-min. and 659 4-and 1-min. plates, of which we now have accumulated 191 and 220 acceptable plates respectively. There are thus a substantial number of plates yet to be taken, and since there are several concurrent W&S programs only about one-third of the time available to us is presently being devoted to the 10° survey.

Now that these northern plates are becoming available, I have again begun an early-result program. There are two reasons for doing this. The first is that the plates go to approximately $m_{pg} = 10.5$, i.e., appreciable fainter than the HD. Thus if interesting new objects are below the HD limit they will not generally be noted unless some such search is made

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for them. And second, some HD objects are of sufficient interest that they deserve rapid publication. A first paper, listing 175 objects found on the first 100 fields to be covered from Kitt Peak, is in a recent issue of the Astronomical Journal.

I will now show a number of slides illustrating the types of things that show up on the plates. Some are taken from the Atlas of Objective-prism Spectra published by Houk, Irvine, and Rosenbush (1974). The first slide shows the O-type stars. HD 102567 is V801 Cen, the x-ray source. The second shows some B5 stars, and a nice B-type shell, HD 33599. The next shows the stars near A5, with a good A-type shell, HD 104237, which is probably a companion to ε Cha, a metallic-line star and a peculiar A. The shell star is a 6th mag. object which has bright Hα but nothing much else seems to be known about it. The bottom star, HD 8783, is a striking Sr-Eu-Cr star. It is 7.5 mag., and yet is not classified as peculiar in the HD. Thus it is evident that the HD missed practically all of the fainter Ap stars. On our plates, the silicon stars are the easiest to detect; the manganese and λ Boo stars are almost never detected. One phenomenon occasionally seen in the Sr stars is a marked shallowness of the K line. The behavior of the Sr λ4077 line is rather odd: it is surprisingly strong in many Am stars and I have also noted it to be anomalously strong in some stars that otherwise appear to be quite normal F's. Incidentally, at first we did not publish the new metallic-line stars, as we thought them too common to be of interest. I have changed my mind on this point. Distinguishing between Am and δ Delphini stars is very subtle and uncertain; some stars classified as either may be normal objects. Also it is very difficult, if not impossible, to distinguish between true Am's and composites consisting of late A or early F giants and earlier type main sequence A stars. If the late-type component shows a G band the distinction is clear, as in the case shown on the next slide. There is no doubt that this is a composite spectrum, with the late-type star being a G or K giant.

Turning to later types, we have the Ba II stars and the stars that should but do not show the G band. The former are rather easily confused with normal supergiants or even some giants with strong CH and CN features. Stars can be erroneously classified as no-G-band stars if they are actually too late in type to be expected to show the G band, and one must be quite careful about this. Another notable thing in late-type stars is the occasional presence of strong Ca II emission, as in the next star HD 81410 = IL Hya. This is an extreme case, but weaker cases are fairly common. These stars are without exception spectroscopic binaries related to if not actually RS CVn stars. The T Tauri stars, which might be confused with them, do not show up appreciably in my survey. However, one does have to take some care in the discovery of emission objects. The next slide shows a spectrum that seems to have nice hydrogen and Ca II emission, but it is actually two stars a few seconds apart lined up in a north-south direction! At the latest types we note the carbon and S stars and the M-type Miras with their characteristic abnormal Balmer decrement. Dwarfs of types KO and later are easy to classify and I am publishing these if they are not already known. And, of course, one

occasionally finds a symbiotic, with strong He II λ4686, or a flare star with a normal Balmer emission decrement.

There are even more exciting objects: one occasionally sees subdwarf O's or B's, though these are generally already known. The B stars with strong helium lines, like HD 168785 shown in the next slide, are of great interest to theoreticians. Now lest you jump to the conclusion that everything is easy, let me show you one of our mistakes. MacConnell, Frye, and Bidelman (1972) published this star, CoD $-37^{\circ}9248$, as a new hydrogen-deficient F-type star; however, several people have subsequently shown that it is markedly variable in light and is in fact a very weak-lined high-velocity star---persumably a new RV Tauri or semiregular variable that we just happened to catch at the phase when the hydrogen emission just balanced the absorption. I herewith apologize.

Finally I must mention the type of object that is perhaps the most satisfying of all to discover--a star of very low metal abundance. We have found many new ones, of course; in fact most of the known field weaklined giants have been found on objective-prism plates through the efforts of Howard Bond (see Bond 1980)and ourselves. The other day I found a low-metal star that really made my day: it is shown on the last slide. The object is the 9th magnitude star BD $+44^{\circ}493$, which has a proper motion of about one-tenth of a second per year. This star has been classified twice as a B star, but it is clearly an extremely weak-lined G, and probably a giant as well. This discovery is a convincing illustration of the value of the early-result program, for the star, not being in the HD, would not have been classified by Nancy Houk and may well have remained unnoted for years. I suspect that it will turn out to be one of the most metal-deficient objects ever found, and I trust that it will not long remain in the obscurity from which it has finally partially emerged.

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DISCUSSION

L.O. LODEN: Can you give some numerical value of the completeness of the discovery of chemically peculiar stars, particularly with respect to the type of peculiarity? (A significant systematic tendency may impose a selection effect upon subsequent frequency statistics.)

P. BIDELMAN: I'm afraid not. But for the more conspicuously abnormal stars we should be very nearly complete, in the relevant magnitude range. For the marginally abnormal the incompleteness will be serious. I should add that all of the objects noted on the objective-prism plates should be subjected to further spectroscopic and/or photometric study before they are accepted as completely certain. We are preparing only finding, not definitive, lists. Also we are only publishing objects not previously known.

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