In this connection it may be mentioned that while examining this star in 1890 with the 36-inch, I found a new pair in the field which may prove to be an interesting system. This is a 9m star 31ˢ.7 following, and 5′ 42″ south of 95 Ceti. The components are equal, the distance being about 0″.4 ($\beta$ 1177).

CHICAGO, Aug. 8.

## A FIELD FOR WOMAN'S WORK IN ASTRONOMY.*

MRS. M. FLEMING.

In the earliest records of ancient Greek History we can trace the great interest which centres in the heavenly bodies, and in Astronomy, the greatest of all sciences, but in no way do we find women connected with the study of this science until a comparatively recent date. Caroline Herschel, Mary Somerville and Maria Mitchell were, as women, pioneers in this work. We cannot say these were the only women of their time capable of devoting themselves successfully to this work and of adding to our knowledge of the heavenly bodies and of the laws which govern them. Caroline Herschel and Maria Mitchell had rare opportunities afforded them, the former in that she had a brother who was thoroughly devoted to the work. Probably through him her interest was aroused and she became his assistant and his untiring companion in his researches. Maria Mitchell, in all likelihood, acquired a similar interest in Astronomy from her father, and her high standing as an astronomer is acknowledged by all connected with the study of this science. A great many women of to-day must have a similar aptitude and taste for Astronomy and if granted similar opportunities would undoubtedly devote themselves to the work with the same untiring zeal, and thus greatly increase our knowledge of the constitution and distribution of the stars.

The United States of America is a large country, with a large-hearted and liberal-minded people. Here they have made room for comers from all other countries, have welcomed them and have given them a fair open field and equal advantages in pursuing their labors or studies, as the case may be. There is no other country in the world in which women, not as individuals, but as a class, have advanced so rapidly as in America, and there is no

* Read at the Congress of Astronomy and Astro-Physics, Chicago, August, 1893.

other country in which they enjoy the same unlimited freedom of action which affords them the opportunity to find their own level. In their studies they encounter very little narrow-mindedness or jealousy in their brother students or fellow workers in the same field of research, but in general they are treated with the greatest courtesy, encouragement and assistance being graciously accorded. Women, therefore, who have taken up any branch of science, or indeed work of any kind, need not be discouraged in it even if one or two of the great mass which goes to make up the whole in their superior judgment refuse to give credit to their work. Labor honestly, conscientiously and steadily, and recognition and success must crown your efforts in the end.

Photography, as applied to Astronomy is one of the greatest advances which has been made in this the oldest of sciences, and this same advance has opened up a comparatively extensive field for woman's work in this department. Dr. Henry Draper of New York was the first scientist who photographed successfully the lines in a stellar spectrum. His wife, Mrs. Anna Palmer Draper, was his constant companion and assistant in all his experiments and researches. On the interruption of his valuable investigations by his sudden death in 1882, Mrs. Draper, knowing the great value of the work already done, decided that the investigations should be continued at the Harvard College Observatory under the direction of Professor Edward C. Pickering, and she set aside a liberal sum of money to be used for this work, thus founding the department known as "The Henry Draper Memorial." In 1886 there were three women computers engaged in the work in this department; at the present day there are twelve women engaged in the same or in similar work. Miss Catherine W. Bruce of New York has shown her appreciation of the photographic work now being carried on at the Harvard College Observatory by her generous gift to that institution of $50,000 for the erection of a photographic telescope of the largest size. The Observatoy has a corps of about forty assistants, seventeen of whom are women, and twelve, as stated above, are engaged, more or less, on the photographic work.

The photographs obtained with the various telescopes now in use at the Harvard College Observatory in Cambridge, and at the auxiliary station near Arequipa, Peru, are of various classes, the most important of these being chart plates having exposures of from ten to sixty minutes or more, spectrum plates having exposures of from ten to sixty minutes, and trail plates having sev-

eral exposures of a few seconds duration. The women assistants are not engaged during the night in taking these photographs but find their time during the day sufficiently occupied in examining, measuring, and discussing them, and in the varions computations therein involved. Catalogues, for reference, of the plates taken with each instrument have to be kept up to date, the plates have to be compared with the charts of the part of the sky which they are supposed to represent, in order to check the correctness of the record made by the observer, and to ascertain that the region intended is contained on the plate. The chart plates are then filed carefully away and are used in the confirmation of variable stars or other interesting researches. The most important work at present being done from the chart plates taken with the 8-inch Draper telescope in Cambridge, and with the 8-inch Bache telescope in Peru, is the measurement of the faint stars for standards of stellar magnitudes. These measurements of about forty thousand stars are now being made by Miss Eva F. Leland. She is also engaged in the measurements of the brightness of the stars in clusters. Miss Louisa D. Wells and Miss Mabel C. Stevens have shown great skill and accuracy in making the identification of stars shown in the photographs, with those contained in existing catalogues. The photographs of stellar spectra are all carefully examined in order to detect new objects of interest, such as third type stars, fourth type stars, fifth type stars or those, whose spectra consist mainly of bright lines, and similar to those discovered in Cygnus by Wolf and Rayet, planetary nebulæ, and variable stars. All of these except the first named class differ so much from the general mass of stellar spectra, that a trained eye has little difficulty in detecting them on the photographic plates, even although the objects found are sometimes as faint as the ninth magnitude. If an object is detected on any of the photographs showing a spectrum of the third type, having also the hydrogen lines bright, it is at once suspected of variability, since only variables of long period are known to possess this peculiarity. The catalogues of the plates taken with the different instruments are then consulted, and a list is made of all the plates covering the region of the star suspected of variability. So you have, ready to your hand and for immediate use, the material for which a visual observer might have to wait for years and certainly for months. This material must also be considered more reliable, for in the case of a visual observer, you have simply his statement of how the object appeared at a given time as seen by him alone, while here you have a photograph in which every star

speaks for itself, and which can at any time, now or in the years to come, be compared with any other photograghs of the same part of the sky.

Many interesting discoveries have been made from the study of these photographs of stellar spectra. First in importance among them, was the discovery that ζ Ursæ Majoris is a close binary star, the two components revolving around each other at a velocity of about a hundred miles a second, in a period of about fifty-two days. This discovery was made by Professor Edward C. Pickering, his attention being first attracted to it by the fact that in the photographs of the spectrum of this star, the lines appear sometimes double and at other times single. This discovery led to the finding of a second object of this same class, β Aurigæ, by Miss Antonia C. Maury. This last star has attracted public attention much more widely than ζ Ursæ Majoris and may be considered more interesting in that the period of revolution of the two components is only 3 days 23 hours and 36.7 minutes. ζ Ursæ Majoris and β Aurigæ are such close double stars that they could not possibly be separated visually with the most powerful instruments at present in use. A third object of this class is suspected in β Lyræ which shows a similar change, or rather it shows a reversal in the position of the bright lines with regard to the dark lines in its photographic spectrum, that is, they apparently cross and re-cross each other. This is doubtless associated with the variation in the light of this star since the period is the same for both. The examination of the photographs of the brighter stars has been made by Miss Maury who has also been engaged on their classification. The micrometric measurements of the lines in the photographic spectra of the bright stars have been made by Miss Florence Cushman.

From the examination of the photographs of stellar spectra, thirty-eight stars having spectra of the fifth type have been added to the sixteen previously known, making the known number in all fifty-four. Three of the stars in this list have been discovered during the past few days and have not as yet been announced elsewhere. Twenty-three new variable stars have been discovered in this same examination of the photographs, and before being published each and all were confirmed by Professor Pickering. Two of the twenty-three have not yet been announced elsewhere since one of them was discovered only yesterday. This star is in the wonderful southern cluster ω Centauri, the finest in the sky, and being so situated would probably never have been discovered by other means than photography.

The other star is in Columba and is the first variable discovered in that constellation. Its position for 1875 is in R. A. $5^h\ 45^m\ 41^s.9$, Dec. $-29°\ 13'.7$.

One must not always cling to the earliest method of accomplishing anything and assume that because it was the earliest and has held sway for centuries, it must consequently be the best, and also the only way. Where should we be to-day if we did not advance steadily in all things? Taking light for instance, first we have rude torches and rush lights, then candles by which the day was measured off into hours, this followed by lamp light, later by gas light, till now we have electricity to light our streets and our dwellings. And powerful as electricity is in itself for all purposes to which it has been applied, who among us can say that in it we have attained the highest degree of perfection in illumination? So it is with everything else we may take up, and so it is with astronomy. And thus while the old time astronomer clings tenaciously to his telescope for visual observations, astronomical photography is leaving him far behind and almost out of the field in many investigations which nevertheless he still continues in his own way, trying also to maintain that, as stated above, it must be the best, if not the only way. If photographic work is to be entirely ignored by the astronomers of the old school as they may be called, because, as they themselves say, they have no knowledge of photography, and not having the means at their command, do not wish to acquire a knowledge of it, what is to become of the researches planned and undertaken by the Astro-Photographic Congress of Paris, in which astronomers of all countries have united? We may safely say that the younger, more advance guard of civilization will uphold photography and encourage it as applied to astronomy, as in other scientific researches in which it is also successfully employed.

A new variable star in the constellation Delphinus was discovered from the photographs some time ago, and was announced in "The Sidereal Messenger," Vol. X, p. 106. Two skilled visual observers undertook to observe it in order to confirm, or refute, its variability. One arrived at the conclusion that it was not variable and was always about the ninth magnitude, while the other also found that the star was not variable, but according to his observations it was always about the eleventh magnitude. When they met together to discuss this difference in magnitude, they discovered that each had been observing a different star, and further, that neither of them had observed the variable. No such error could have occurred from the comparison of the photographic charts.

Unlike telescopic observations, the photographs are available always, at any time during the day or night, for consultation and examination. Therefore, while an observer with a telescope, be it even the most powerful that can be made, is at the mercy and dependent upon the state of the weather for his observations, the discussion of the photographs goes on uninterrupted and is undoubtedly much more reliable than visual work, since when a question of error in observation arises, anyone interested in the research can, at any time, revise the original observation by another and independent examination of the photograph.

Given the instruments, and materials required, with a knowledge of how the instrument is used, you can obtain in one night what would represent years of hard labor in visual observation, and in the necessary computation involved in reducing and charting these same observations. Even when finished the visual observer's chart may be subject to various errors in the positions or in the brightness of the stars with which he has dealt, but the photograph cannot fail to be an exact and unquestionable record which can be consulted and compared with others years hence, and thus serve to prove or disprove variations in light, changes in position, and in the case of the spectrum plates, changes, if any, in the constitution of the stars. Thus on a photographic plate, on which it has taken only a few minutes to reproduce the portion of the sky covered, you have a true chart of the stars in that part of the sky at that time, the limiting magnitude being dependent on the duration of the exposure and also on the sensitiveness of the plate used.

In a catalogue of variable stars recently published and entitled "Second Catalogue of Variable Stars," a more correct title would be "Second Catalogue of Variable Stars discovered Visually," since in it no weight is given to photographic observations further than is necessary to enable them to swell the list of stars discovered visually. Stars discovered photographically which have been announced as variables, and have been proved beyond doubt to be variables, are here credited as "suspected."

In conclusion, while I may be thought to have strayed far afield from the subject on which I was supposed to address you here, the investigations and researches described above are those in which the women in this department are engaged, in which they are thoroughly interested, and in which they are becoming trained and competent assistants.

While we cannot maintain that in everything woman is man's equal, yet in many things her patience, perseverance and method

make her his superior. Therefore, let us hope that in astronomy, which now affords a large field for woman's work and skill, she may, as has been the case in several other sciences, at least prove herself his equal.

HARVARD COLLEGE OBSERVATORY,
Cambridge, Mass., August 4, 1893.

## ω CENTAURI.*

SOLON I. BAILEY.

The cluster ω Centauri lies just within the northern border of the Milky Way at R. A. $13^h\ 19^m\ 16^s$; Dec. $-46^\circ\ 49'.5$ (1875, Gould).

All the stars within a radius of 5° are of the sixth magnitude or fainter. To the naked eye the cluster appears as a hazy star of less than the fourth magnitude. In a field-glass, it becomes a globular mass of nebulous light, dense at the centre, and gently fading away at the border. The globular form is in general very perfect, but to the north it appears slightly flattened. With a telescope of high power it becomes a maze of faint stars, well defined and separated, but projected, toward the center of the cluster, upon a background of faint nebulous light. Some interesting photographs of this cluster have been made recently with the Boyden telescope of 13-in. aperture and 16 feet focal length. A brief study has been made of the number and distribution of the stars composing this group as shown on one of these photographs. The plate was made May 19, 1893, and the exposure was two hours. The 8-in. finder, which had been previously used for purposes of following, was found after many trials to be incapable of giving sufficiently exact results for this work, and an eyepiece was inserted into the field of the main telescope itself. By this means the photographic images were greatly improved. The precise limits of the cluster are hard to define, but for the purposes of this study a region 30′ square was taken, having for its centre the centre of the cluster. As may be seen from the diagram giving the enumeration, the cluster fills this region fairly well and perhaps extends a little beyond. Within this region is no star so bright as the eight magnitude. A field-glass of good power shows no individual star. Within this region Dr. Gould in his

* Communicated by Edward C. Pickering Director of the Harvard College Observatory.