BUFFALO ASTRONOMICAL ASSOCIATION INC.
BUFFALO MUSEUM OF SCIENCE
HUMBOLDT PARKWAY
BUFFALO NEW YORK 14211

the Spectrum

Editor: Ernst E. Both

SEPTEMBER - OCTOBER 1974

SEPTEMBER MEETING: For our first meeting of the new season we are very happy to present Mr. Ken E. Chilton, President, Hamilton Chapter of the Royal Astronomical Society of Canada, who will lecture on "Unusual Astronomical Theories." Mr. Chilton is by profession a teacher and also acts as the editor of Orbit, the newsletter of the Hamilton Centre, R.A.S.C. It is our great pleasure to Welcome Mr. Chilton! Refreshments will be served after the meeting. The meeting starts promptly at 8:00 p.m. (EDT), Club Room, Buffalo Museum of Science, September 13 (Friday), 1974.

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OCTOBER MEETING: The second meeting of the new season (Friday, October 11, 1974, same time, same place) will feature Orrin Christy in a lecture entitled "Astro-Logical Tides of Solar Activity" and, as far as we know, has absolutely nothing to do with your horoscope, but rather with the Sun's influence (weather-wise) on the Earth. It promises to be a very interesting meeting and we are very happy to Welcome back Orrin Christy! Most of our members will know Mr. Christy, if not as the son of our President, as a very active observer and member of our own BAA. We hope to also have a special raffle at this meeting, so be prepared to spend some money for the benefit of our observatory. The item to be raffled off is a secret, but should be well-worth a few coins. Refreshments afterwards in the lounge as usual.

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SAD NEWS: INFLATION REACHES THE BAA! For some years now we have kept the membership dues as low as we possibly can, despite inflation and increased financial obligations. It is therefore with regret that we announce that our dues have been raised. New membership dues are as follows: Single Membership = $ 7.50; Family Membership = $ 10.00; Junior and Senior Membership (for retired individuals) = $ 3.00. We are sometimes asked what do we get for our membership dues? Aside from the obvious benefit of associating with fellow astronomy buffs, we may list the following: 1. monthly lectures, at times by well-known astronomers or experts in their fields; 2. membership in the Astronomical League and their quarterly newsletter THE REFLECTOR; 3. a meeting place at the Buffalo Museum of Science; 4. refreshments after the meeting (while it is true that we pass around a "hat" for additional funds for refreshments, nobody who does not want to contribute to this fund is denied sustenance); 5. the by-monthly newsletter THE SPECTRUM (if it does not contain things you like, let us know. We can change it easily. So far nobody has told us what they'd like to read in it); 6. The use of an excellent 12.5-inch reflector at the BAA Newstead Observatory; 7. free advice on telescopes and related problems at the monthly meetings of the Instrument Section (4th Friday of every month, at the Museum); 8. star evenings outside the city on every week-end (almost) during the summer months. One could extend this list. For my money, it's quite a bargain.......................

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THINGS TO COME THIS SEASON: Sometime in November we will participate in another Buffalo Philharmonic Pops Concert (details at the September meeting) - an excellent opportunity to support your local orchestra as well as our planned observatory at the Audubon Society's Beaver Meadows Environmental Center; during October the Buffalo Museum of Science presents a special, large exhibit on LASERS, THE NEW LIGHT (Oct. 4 to Nov. 4), featuring real working lasers with demonstrations, displays, films, holograms, lectures, and tours. Don't miss this exhibit!!! * * * * * * * * * * * * * * * *

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* A TRIPLE STAR IS GRADUALLY DISCOVERED * By Dr. Frederick R. West

Aitken Double Star (ADS) 14893 is a triple star system that consists of a visual double star with components that always show apparent separation of 0"25 or less; one of the nearly equally bright components is a single-line spectroscopic binary. I first obtained a spectrogram of ADS 14893 in June, 1965. At that time I was observing the visual double star Struve 2173 which had just passed through a node of its orbit and the difference in radial velocities of the two component stars was near maximum. I was trying to detect and measure the radial velocity difference for the Struve 2173 stars and took a spectrogram of ADS 14893, also possibly near a node, to fill the last half of an observing night. This was the first of 70 high-dispersion (between 8.9 and 23.7 angstroms per mm, inverse dispersion) spectrograms that now exist of ADS 14893.

Measurement of the spectrogram showed a radial velocity difference attributable only to the previously known spectroscopic binary, about which nothing save its existence was known according to a letter from Dr. Alan Batten. I therefore requested and obtained three consecutive nights on the coude spectrograph of the 84-inch reflector at Kitt Peak, Arizona (where the 1965 spectrogram was obtained) in November 1968. A single spectrogram was obtained on each night, and although the spectrogram quality was poor (mainly due to the use of a grating improperly blazed for the yellow light to which the spectrograms were exposed), the spectroscopic binary radial velocity changes showed its orbital period to be a few days. After reduction of these spectrogram measurements, I was alloted five half-nights in July 1969 on the 84-inch at Kitt Peak. In spite of partly cloudy skies, at least two spectrograms were obtained each night, with a total of 15 spectrograms exposed of ADS 14893. Dr. Helmut Abt obtained two additional 84-inch coude spectrograms in August and October of 1969. The 1969 spectrograms along with those from 1965 and 1968 showed that the orbital period of the spectroscopic binary is about 2.236 days, while its radial velocity varies about the radial velocity of the center of mass (of the spectroscopic binary) by as much as 75 km/sec greater or less. These values are close to those derived by using all of the 70 spectrograms.

After arrival in Buffalo, I, with financial support of the Research Foundation of the State University of New York, continued research on double and multiple stars, with ADS 14893 first on my priority list. Although I had acquired 21 high-dispersion spectrograms of this star system by the end of 1969, only 6 of those were tied into radial velocity standard stars (stars with constant and well-determined radial velocities), which are needed to correct for systematic errors in the spectrograph or on the spectrogram. Such standard stars increase the reliability of a psectroscopic binary orbit and are needed if anything meaningful is to be derived for the measured radial velocity variation of visual double star components, since their large separations usually allow variations of only a few km/sec over years or even decades. The spectrograms funded by the above grant were obtained with the Cassegrain-focus spectrograph of the 74-inch reflector at the University of Toronto's David Dunlap Observatory in Richmond Hill, Ontario. All but one of these spectrograms have dispersions of 11.8 angstroms per mm. 17 spectrograms were obtained during three observing sequences in July, August, and September 1970, with two or three radial velocity standard star spectrograms on all but one observing night. Dr. Abt obtained three supplemental ADS 14893 spectrograms at Kitt Peak during November and December 1970 without standard star spectrograms.

As measurement of the spectrograms proceeded on the Gaertner measuring comparator in the Physics Department at State University College at Buffalo, an approximate idea of the spectroscopic binary's orbit size and shape emerged. Both visible components of ADS 14893 are main sequence (dwarf) stars of spectral class F7 to F8, hence one expects each to be slightly more massive than the Sun. The spectroscopic binary orbit size and shape requires a minimum mass of 0.65 that of the Sun for the third star (the invisible star C), which occurs for a spectroscopic binary orbit plane inclined 90° to the plane of the sky; such an inclination would require the spectroscopic binary stars to eclipse each other. Dr. Kwan-Yu Chen observed ADS 14893 photometrically with the University of Florida's 30-inch reflector, first jointly with me in August 1969, then alone in October 1969 - no eclipse was found. Either the mass of star C is much smaller than that for a main sequence star, or the orbit plane's inclination to the plane of the sky is considerably less than 90°, in which case star C must have a mass greater than 2/3 that of the Sun. With this lower limit for the mass of star C (not much less than the estimated masses of the two visible components) the possibility to detect its spectrum was considered. I surmised that the spectrum of star C (compatible with the estimated mass range of star C) would be that of a G or K class dwarf, which would appear stronger relative to the two F star spectra in red and infrared light than in the blue light usually used for David Dunlap Observatory spectrograms. F stars radiate most intensely near blue wavelengths while K stars radiate in the orange; especially promising spectral features of a G or K class spectrum are the neutral calcium red and infrared triplet lines and the red potassium line. Therefore, in July 1971, after considerable preparation by Dr. John F. Heard of David Dunlap Observatory and myself, one red-infrared (I-N emulsion) spectrogram each was obtained of ADS 14893 and the radial velocity standard star at 23.7 angstroms/mm. No trace of the third star's spectrum was found - only spectral lines from the two visual components and the Earth's atmosphere were seen. It began to seem that star C might be underluminous for its mass.

Eleven blue-light spectrograms were obtained on August 5 and 6, 1971, with three spectrograms of radial velocity standard stars the first night and four the second. One underexposed spectrogram of ADS 14893 along with one of a radial velocity standard star was obtained just before sunrise April 8, 1972, while six spectrograms were obtained on September 15 and 16, 1972; three standard star spectrograms were obtained on each night, all at David Dunlap. Measurement and reduction showed that the spectroscopic binary has a small but probably definite orbital eccentricity. The radial velocity of the single star slowly decreased from -13.7 km/sec in July 1969 to -20.8 km/sec in September 1972, not incompatible with a nearly circular orbit of 12-year orbital period similar to that calculated by Dr. P. Baize in 1959 for the visual binary orbit of ADS 14893. The 1971 spectroscopic binary radial velocities indicated a mass ratio of the spectroscopic binary to the single star of about 1.7, while the September 1972 radial velocities indicated a mass ratio near or greater than 2. When another David Dunlap spectrogram was obtained in June 1973, measurement showed the single star had a radial velocity of -31.3 km/sec, a change of -10.5 km/sec since September 1972! An even greater radial velocity change occurred in the next two months, when one spectrogram on August 19 and five on August 20, 1973 (all with radial velocity standards) showed radial velocities of -46 to -50 km/sec for the single star which was then at or near the descending node of its orbit! The visual binary orbit is evidently highly elliptical, contrary to the orbit published by Dr. Baize.

Dr. Abt obtained a spectrogram of ADS 14893 along with that of a radial velocity standard star on December 13, 1973, which showed that the radial velocity of the single star was then -26.9 km/sec. From the change in radial velocity deduced for the spectroscopic binary center of mass during 1973, opposite in sign to that found for the single star, the mass of the spectroscopic binary has been found to be over twice that of the single star. Intensity tracings were made at David Dunlap Observatory in 1973 of two spectrograms where the spectroscopic binary was near maximum and minimum radial velocity (the ascending and descending nodes of its orbit). This insured good separation of the component spectra and small change of the spectroscopic binary radial velocity during the exposure. The tracings were studied: 1. to determine the relative luminosities of the two visible stars, and 2. to check earlier spectral classifications, the most recent of which is due to Dr. E. Harlan (published in 1974). The spectroscopic binary may be rotating synchronously with its orbital revolution, hence faster than the single star; most of its spectral lines are broader than those of the single star. So the luminosity ratio of the two stars had to be determined by detailed study of the equivalent widths of a few pairs of relatively unblended lines on each plate tracing. The single line spectroscopic binary (star B) was found to be less luminous than the single star, now designated star A according to the usual visual binary nomenclature. Their magnitude difference is $0.04^m \pm 0.02^m$; such a small magnitude difference can easily explain the equal brightnesses assigned to stars A and B by most visual observers. Both stars exhibit relatively stronger lines from singly ionized metals than does the Sun, which indicates somewhat hotter photospheres for ADS 14893 A and B than for the Sun. Of the two components, star A seems to have a slightly higher degree of ionization hence a hotter photosphere. The spectrum of star A is classified as F7V, that of star B as F8V (the latter is Harlan's classification of the composite ADS 14893 spectrum).

In June 1974, I obtained two more spectrograms of this star system along with two standard star spectrograms; the radial velocity of star A was then -16 km/sec, within its usual limits. These were incorporated into the solution for the spectroscopic binary orbital elements, some of which are as follows:

1. Orbital period .... P = 2.2361 days
2. Orbital eccentricity .... e = 0.0635
3. Amplitude of radial velocity variation .... K = 76.714 km/sec
4. Projected semi-major axis of star B's orbit
   around spectroscopic binary center of mass ... = 2,300,000 km (= $a_B \sin i$)
   Mass Function of star C .... $f(M_C) = 0.104$ solar mass units

This orbit will soon be submitted for publication in more detail in a professional journal. It is best fitted by a mass ratio of the spectroscopic binary mass to that of star A of $M_B + M_C$ divided by $M_A = 2.257$, and a center of mass radial velocity of ADS 14893 of -20.7 km/sec. Two interesting conclusions have now been reached: 1. Star C is the most massive star of the three in ADS 14893, yet its spectrum cannot be observed! The magnitude difference between stars A and B and their spectral classification leads to estimated masses of 1.1 to 1.2 solar mass units for them, with star B perhaps the slightly less massive of the two. While the above mass ratio is not certain, it is almost certainly between 2.1 and 2.4, for the 1973 radial velocities for star B diverge badly from the computed radial velocity curve for mass ratios outside those limits. Certainly star C is underluminous for its mass which is probably between 1.2 and 1.6 solar mass units. It is most probably a degenerate star at the end of its evolution; a white dwarf or neutron star. Evidently the spectroscopic binary is a very evolved system, where star B has exchanged mass with star C, perhaps lost mass to interstellar space, and perhaps even to star A. The small radius expected for such a massive, degenerate star (10 to 1000 km) causes star C to be impossible to detect optically. It could only be observed if it were a pulsar or if infalling matter emitted X-rays or radio waves. ADS 14893 is not the optical counterpart of a known pulsar, and its position does not coincide with any X-ray source listed in the third UHURU catalog of X-ray sources. 2. The radial velocity curve of star A indicates that the visual binary orbit is between 5.5 and 7 years, about half that found by Dr. Baize. The small magnitude difference found between stars A and B makes frequent quadrant reversals likely in visual observations and could have led to an erroneous visual orbit. Thus, what initially seemed to be an ordinary main sequence visual double star has turned out to be an interesting triple star. Future spectrograms over the next 8 years should allow the visual binary period to be determined accurately by radial velocity coverage of the next passage by ADS 14893 A through the descending node of its orbit in 1979 or 1980. From the spectroscopically derived orbital elements, earlier visual observations will enable the orbit inclination and apparent semi-major axis to be found. From this, the distance of ADS 14893 and the individual masses of its component stars (A,B, and C) can be drived, which will allow more definite limits on the masses and orbit sizes in this interesting system.

The drastic changes in our concept of ADS 14893 which has resulted from a few years of spectroscopic observation leads one to speculate on how many visual binary orbits of other close-separation visual binary stars are seriously in error and would have to be drastically revised after a few years of high-dispersion spectroscopic observation or, probably in more cases, by space observation from the Large Space Telescope (LST) now acheduled to be orbited by the Space Shuttle in 1980. So perhaps the real message of this study turns out to be that if you want to see visual binary star astronomy realize its true possibilities for astrophysics and stellar evolution within your lifetime, SUPPORT YOUR NATIONAL LST!

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** PIONEER FINDINGS PAINT NEW PICTURE OF JUPITER ** From NASA Release 74-238 (9/10/74)

Information returned by the Pioneer Jupiter spacecraft seems to support the theory that the largest planet in our solar system is a spinning ball of liquid hydrogen, without any detectable solid surface. At best, Jupiter has only a small rocky core, thousands of miles below the heavily clouded atmosphere. And its mysterious Great Red Spot is probably the vortex of a gigantic storm that has been raging along a 25,000-mile front for at least several hundred years. Much of the new information contradicts previous theories on the nature of Jupiter. The brightly-banded planet, big and bizarre, by itself containing more than two-thirds of all the planetary material in the solar system, now seems to have these characteristics: 1. Jupiter appears to be almost entirely a liquid planet, without any solid surface; 2. It seems to have a turbulent interior, much hotter than previously thought; 3. Its magnetic field is much larger than some models predicted, and its radiation belts are far more intense than many expected; 4. Jupiter turns out to be the source of high-energy particle radiation, the only one in our solar system besides the Sun. Some of these particles may be measureable at Earth; 5. At birth, some four and a half billion years ago, the solar system giant was far hotter than had been believed possible; 6. The circulation pattern of Jupiter's atmosphere is far different from that of Earth's. For example, the familiar circular cyclones and anti-cyclones of the Earth are stretched completely around Jupiter. This is probably due to the effects of heat radiation from the planet's interior, and Jupiter's 22,000-mile-per-hour rotational speed. This "weather-stretching" accounts for Jupiter's semi-permanent, planet-girdling, alternating brown-red and gray-white cloud bands; 7. The density of Jupiter's four planet-sized moons is directly proportional to their distances from the planet. It decreases from the density of rock for the closest large moons (IO and EUROPA) to the density of water-ice and rock mixture for the outer (GANYMEDE And CALLISTO). This outward decrease is probably due to the great amounts of heat that were radiated by the planet at its formation; 8. IO has a tenuous atmosphere, perhaps containing hydrogen, nitrogen and sodium. GANYMEDE is known to have an atmosphere, and the other two big moons probably also have atmospheres. Pioneer pictures of the largest moon, GANYMEDE, are still being processed, but seem to show maria and highlands, somewhat like those on our Moon and on Mars; 9. Pioneer 10 has shown that Jupiter's gray-white zones are cloud ridges of rising atmosphere circling the planet, and looming 12 miles above the cloud belts, while its orange-brown belts are cloud troughs of descending atmosphere, probably 12 miles deep. The Great Red Spot appears to be the vortex of an intense storm, towering some five miles above the surrounding cloud deck.

Pioneer 10 provided man with his first closeup look at the giant planet on Dec. 5, 1973, wnen the spacecraft flew within 81,000 miles of Jupiter. A sister spacecraft, Pioneer 11, launched April 6, 1973, is scheduled to fly by Jupiter on Dec. 3, 1974, passing within 29,000 miles. It will then continue on to Saturn.

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* METEOR SHOWERS FOR SEPTEMBER AND OCTOBER * By Darwin Christy

There is no conspicuous shower in September, but two smaller ones are known. From the radiant at RA 04h 04m, decl. +36° come the Epsilon Perseids on the 11th. Eleven days later expect the Alpha Aurigids with their radiant at RA 04h 56m, decl. +42°. These are related to the February Aurigids - don't expect either of these two to be very spectacular.

In October things begin to get better: on the 2nd the Quadrantides appear for the second time during the year; though they were great in January of this year, they will be unfavorable for us this October. Their duration is only 6 hours long - during the daylight hours!!! The Draconids follow on the 9th from a radiant at RA 17h 40m, decl. +55°. They derive from comet Giacobini-Zinner and are not to be confused with the June Draconids. Duration is for only a couple of hours and they are considered a swarm with a period of 33 years. In 1933 there were as many as 20,000 seen in one hour. The Epsilon Arietids show on the 17th (if you can find them).

Believed to come from comet 1910 II (Halley's) are the Orionids on the 21st. An hourly rate of 20 may be expected. The meteors in this shower are short and swift, coming from a radiant located at RA 06h 08m, decl. +15°.

Comet 1739 gave up some of its debris to produce what is now known as the Leo Minorids. They are nothing to cheer about, but should you see a reddish, extremely long and slow trail, lasting as long as 5 seconds, you may have seen one. GOOD HUNTING!

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FOR SALE, FOR SALE: 2.5-inch Unitron Refractor, new (in 1966) for $ 225.-, selling for $ 130.- If interested, contact John Breese, 75 E. Depew Ave., Buffalo, N.Y. phone 832-9193.**** IF YOU HAVE ITEMS FOR SALE, TRADE, GIVE-AWAY CONTACT YOUR SPECTRUM!

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FIRST CLASS
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