FROM

HALIFAX CENTRE R.A.S.C.
1747 SUMMER ST.
HALIFAX, N.S.

Feb? 1971

TO

ROYAL ASTRONOMICAL SOCIETY,
252 COLLEGE ST.,
TORONTO, ONTARIO.

NOVA NOTES

THE PROPERTY OF:
THE ROYAL ASTRONOMICAL
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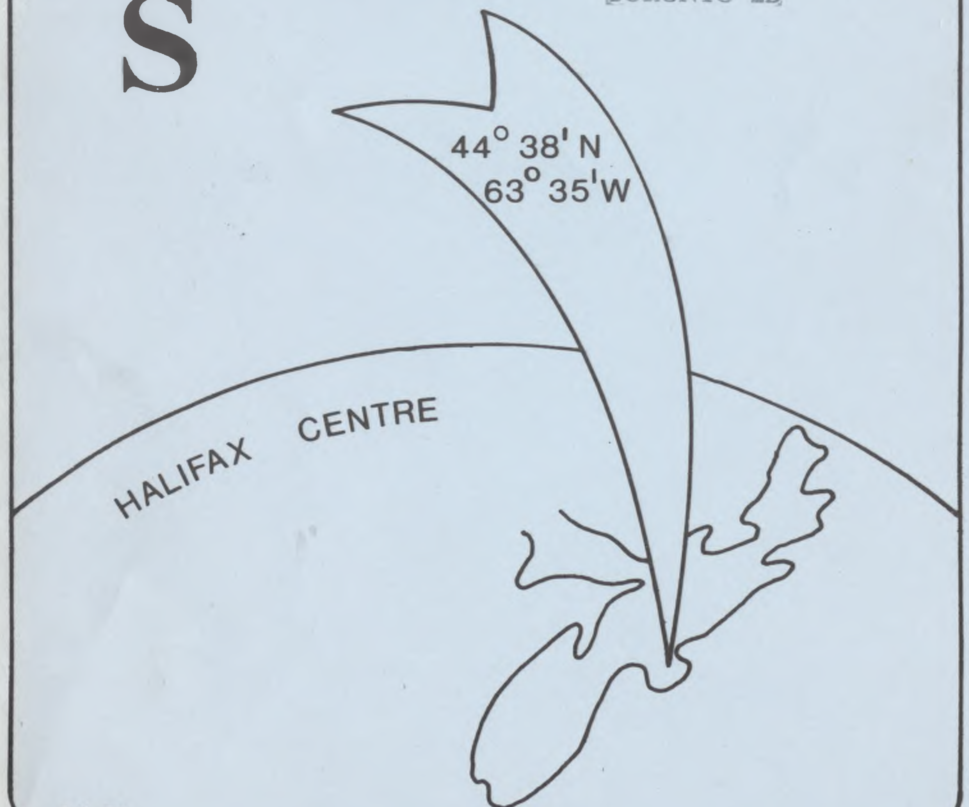

E.H. 70

EDITORIAL.

In the last few years, astronomers have been able to get close up pictures of the near and far sides of the moon; of Mars, which fail to show any canals, but do show a cratered surface; and of Venus, which photographically presents no more detail of the surface at a thousand miles than at ten million miles. Aside from these photographs very little is known of the surface details of the other planets and many of the details of the Universe are hidden from us.

The reasons for this are threefold; the distances involved; the practical limit of earth bound telescopes; and the earth's atmosphere through which even the largest telescopes on top of mountains must look.

We can only overcome the distance problem by travelling through space. Either manned or unmanned trips to the planets will probably be made in the near future and of course this is the best answer of all for detailed planetary study. It is unlikely any telescopes much larger than the 200" Hale will be built. Attempts to lick the atmosphere problem are now being made.

The sharpest photograph ever taken of Uranus was obtained with a 36" telescope under a balloon at 80,000 feet when Uranus was only 1.6 billion miles from earth (only!) its closest approach, presenting a disc 4 seconds of arc across (or 1/450 the size of the earth). The 1/10 of a second resolution of this picture is hardly enough to show any detail (to my eye the picture just appears as a speckled circle) but it is still 10 times sharper than any taken from earth. Stratoscope II also photographed Jupiter and its satellite Io as well as the nucleus of a Seyfert galaxy. This was the work of Danielson and Schwartzchild of Princeton University Observatory.

The other answer to the atmosphere problem is an orbiting Astronomical Observatory (O.A.O). NASA has tried three times to launch such an observatory. Only the second attempt, in December 1968 has succeeded, and exceeded expectations about its performance. It has seen things no earth based scope will ever see. It has mapped the Universe in ultra-violet light, discovered ozone on Mars, the hydrogen cloud around a comet; that ordinary galaxies produce much more U.V. than expected and that the hottest stars are burning hydrogen even faster than believed.

The fact that last November's abortive launch cost $98 million and could have bought 5 Palomar's makes many astronomers shudder, but must be chalked up to experience.

Regardless how the foregoing makes viewing from earth sound, we are not completely blind and there are many beautiful sights waiting to be looked at. A few of us in the next few months may be in a better position to see them. The Society has received several mirror-grinding kits, and several members will be grinding - 2 Richfield 15.5 cm (6") - think metric telescopes and 3 - 20.6 cm (8") telescopes. There should be a lot of good viewing ahead and besides I've been told that being in orbit is just a state of mind.

J.S.

Ref: Natural History Feb. 1971, Pg. 46
Dec. 1970, Pg. 53

N O T I C E   O F   M E E T I N G

Date: March 19, 1971.

Place: Tupper Building

Time: 8:00 p.m. sharp

Speaker: J. A. Wheeler of Princeton University

Subject:- Our Universe: The Known and the Unknown

Would members please note, that for this month only, we shall be going to the Tupper Building. It was decided that as this lecture coincided with our regular meeting night, members might wish to take advantage of hearing this lecture.

Newsletter is printed: Thanks to the goodwill of the Nova Scotia Museum of Science

The regular monthly meeting of the Royal Astronomical Society of Canada, Halifax Center, was held on February 19, 1971. Guest speaker for the evening was Dr. Roy Bishop. Dr. Bishop spoke on the subject of Astrophotography. This was an extremely informative lecture. For the benefit of the members who were unable to be present on that evening, a copy of Dr. Bishop's talk, or more correctly, an outline of the points which he discussed, is included with this Newsletter. We were fortunate in being able to view some beautiful slides taken by Dr. Bishop. Meeting adjourned at 10:30. Coffee was served. E.H.

NOVA NOTE'S
ASTRONUTS.

NOTES ON ASTROPHOTOGRAPHY*

Essential Points

1. Good optics.
2. Steady supports (tripods, mounts, drives).
3. Good seeing (steady atmosphere) for high power work.
4. Your own darkroom (for black and white photography).

Camera

Any good camera can be used for astrophotography; however, 35 mm (or 2¼"x 2¼") SLR cameras are the most versatile. With such cameras shutter recoil vibration can be avoided for exposures of $t > 1s$ by using a "cardboard shutter".

Lenses: The best is none too good. ($)

Filters: Most useful: K2 (yellow) with refractors.
ND4, ND5 for the Sun.

Camera - Telescope Combinations:

1. Prime Focus: No eyepiece or camera lens.
   May use a Barlow lens to provide a larger and more accessible image.

2. Eyepiece Projection:

   (a) No camera lens: Effective focal length equals the magnification of the telescope times the distance between the eyepiece and the film.
   $EFL = M \times D_{ef}$

   (b) With camera lens: Effective focal length equals the magnification of the telescope times the focal length of the camera lens.
   $EFL = M \times f_c$

   (In both (a) and (b): Effective $f/\# = EFL/D_o$ where D_o is the diameter of the objective lens or mirror.)

Focusing: Usual method: Ground glass screen.
<u>Best</u> method: Clear glass screen with cross-hair on it.
(Adjust so image and cross-hair both sharp.)

*(For the Halifax Center of the R. A. S. C.
R. L. Bishop February 19, 1971)

Films

Recommended all purpose films for astrophotography:

Black and white: Tri-X
Color: Kodachrome-X, H.S. Ektachrome.

(Store in a freezer.)

ASA # stated is valid for moderate light levels and $t < 30s$

"Reciprocity law": $t \propto 1/\text{light}$

For long exposures this law fails in such a way that the effective ASA drops. The effect varies from one film type to another and, in the case of color film, differs among the three color layers with the result that the color balance is upset.

Low temperatures cause ASA #'s to drop at ordinary light levels, but to <u>rise</u> (3 to 10 times !) at low light levels.

Dry ice or liquid CO_2 expansion produces $-190^{\circ}F$.
Use dry air or, better, a vacuum (~ 0.1 torr) to avoid frost.

Develop black and white films in a contrasty developer, such as Kodak D-19, and/or overdevelop some (to x2) for better contrast.

f/# 's

For extended objects the f/# is a useful parameter.

For stars the f/# is of no use. In this case only the aperture area counts.

Sky light limits exposure times:

f/1	$t \sim 10m$
f/2	$t \sim 1h$
f/5.6	$t \sim$ all night

Hence for a given aperture, longer focal lengths (larger f/#) can photograph fainter stars.

Size of finest detail projected on film $\cong \lambda \times f/\#$
(wavelength of light)

Thus for low f/#'s (< 30) need fine grain film to make use of the resolving power of the optics.

Drive

Earth rotates. Use equatorial mount with slow motion drive in R. A. (and declination) to compensate. Observe out of focus star, planet, moon feature, etc. against cross hair in guide scope to track.

No drive needed for: Camera only if $t \lesssim 10s$

Through telescope if $t \lesssim \frac{1}{4}s$

SUBJECT	OPTICAL ARRANGEMENT	TYPICAL EXPOSURE	COMMENTS
Stars	1. For constellation and similar wide angle work, camera alone. 2. Open & globular clusters, camera + telescope	1. 1 s and longer (Stop down to f/3.5 or f/4 for sharp images over a wide field) 2. No wider than f/4, long t.	1. H.S. color film and f/2 will record all stars that one can see with the naked eye in ~ 10 s. (No drive). 2. Large apertures and long focal lengths desirable (i.e. large telescope)
Meteors	Camera alone. Drive preferable to avoid star trails.	No wider than f/2.8 Long t.	Patience required. (& serendipity!) Meteor showers useful.
Comets Aurora Zodiacal light, etc.	(As for meteors)	f/2.8 to f/4 for comets Wider for aurora, etc.	Fast film, wide angle, low f/# lenses desirable. (And a dark sky!)
Sun	Camera + telephoto or telescope. Minimum EFL ~ 20 inches. Danger to eye and camera! Cut intensity with Herschel wedge or N.D. filters (#4 or 5). View by projection, or with objective filter. (Questar).	For ASA 125: $\frac{1}{60}$ s f/16 ND5 filter $\frac{1}{250}$ s f/32 ND4 "	The atmosphere is steadiest in the early morning or just after a cloudy period. Fine grain film is desirable.
Moon	Camera + telephoto or telescope. Minimum EFL ~ 20 inches.	ASA 32 1/60 s f/8 Quarter " f/5.6 Crescent " f/16 Full	Fine grain film is desirable. Good seeing essential. Sun or Moon: Image size ~ $\frac{1}{100}$ EFL.
Eclipses	Camera + telephoto or telescope. Minimum EFL ~ 20 inches. Camera alone for multiple exposure sequence.	Solar: Partial: (As above for Sun) Total: ASA 125 f/11 Prominences: 1/30 s Corona: 1/4 s → 5 s Lunar: Partial: ASA 125 f/11 $\frac{1}{30}$ s → 1 s Total: " " 5 s +	Solar eclipse: Plan well before hand. The minute or two of totality is unreal. A total lunar eclipse in a dark, clear sky is one of the most beautiful sights in the heavens.
Planets	Camera + telescope Minimum EFL ~ 4 ft. " aperture ~ 4" → 6"	f/50 → f/150 desirable ASA 125 f/100 t ~ 1 s → 10 s	Quality of optics and steadiness of drive, mount & atmosphere of utmost importance. Most difficult type of astrophotography.
Nebulae	Prime focus with large aperture and long EFL	Long exposures	Torn between low f/# for light and long EFL for size. Large reflectors (8"+) best.

EPSILON AURIGAE. By H. J. Freeland

"The history of the eclipsing binary ε-Aur is, in many respects, the history of astrophysics during the past six decades." So wrote Dr. Otto Struve in 1962 (1), concerning one of the most baffling stellar systems yet discovered. And now in 1971 ε-Aur has raised its head again to challenge the astrophysicists, and, perhaps, to give us our first observation of the most elusive object in the universe, the cosmic 'black hole'. Firstly, let us survey what is known about the star. ε-Aur is a variable star,(this much has been known for many years), and varies its magnitude between 4.0 and 3.2 with remarkable precision, and with a very precise period of 27.1 years. Close examination of the spectral lines shows periodic shifts in the lines indicating that the star approaches the Earth, and then recedes from us with a very precise period of 27.1 years. The conclusion then is that ε-Aur must be an Algol type eclipsing binary system. That is, the observed star, let us call it star A, has an invisible companion, star B, which periodically passes between component A and the Earth, so causing the observed variations in brightness. This is where the problems begin. Let us continue the survey by quickly describing some further observations. ε-Aur is an eclipsing binary system, consisting of an F2 supergiant, the primary, star A, and an invisible companion, star B. The mass of A is about 35 times the mass of the sun, and the mass of B is about 23 times the mass of the sun. During an eclipse, the only changes occurring in the spectrum consist of the introduction of a few absorption lines, characteristic of a relatively small amount of tenuous, low temperature, gas. If B were in a nuclear burning stage of evolution, then its luminosity would be expected to be about 40% of that of A, but it is invisible. Hence it must be either very large, and so tenuous, or else very small. Suppose B turned out to be just a very large mass of cool gas, in some kind of pre-stellar stage. The distance between the two components is about 35 astronomical units, (35 a.u.), so, the diameter of B could not exceed about 10 a.u., because otherwise its orbit would not be stable. But if it were that small, then the temperature at the centre would have to exceed 10,000°K, and if it were that hot we would certainly see the radiation emitted. So a very large model for B cannot fit the observations. So, maybe it is very small. Its mass is far too great to allow it to be a white dwarf, or a neutron star, besides which, we would certainly be able to detect the radiation from these, and so we are led to the onl remaining alternative, a 'black hole'.

'Cosmic black holes' are what remains after a celestial body has collapsed under its own gravitational field. Within black holes the spacetime continuum, or more precisely, the metric, is so strongly curved that nothing can escape from the gravitational field of the body, not even light. Since light cannot escape, they are invisible, and can only be detected by their gravitational interaction with other bodies. Any amount of matter or energy can be dropped from normal space into these holes, but once in, there is no way out. The existence of black holes is predicted by Einsteins General Theory of Relativity, but not by Newtons theory of gravitation.

So, the suggestion was made this year, by Cameron and Stothers (1), (2), that the unseen component of ϵ-Aur is a black hole, or, as they term it, a 'collapsar'. The suggestion is that a black hole would not contribute to the spectrum of the system, but might have a large envelope of gas trapped around it that would obscure the primary during an eclipse, and so produce the observed absorption lines in the spectrum. All of this seems to coincide quite nicely with observation. However, let us look a little closer at the theory. A black hole would have to be formed by the collapse of the remnant of a super-nova, hence the term 'collapsar', and so presupposes a highly advanced stage of evolution. However, the mass of the B component is <u>less</u> than that of the A component. If B had had a larger mass than A in its pre-nova stage, then it would have to have ejected at leats 12 solar masses during the nova explosion. Such a large loss of mass would have caused the remnant, which is now B, to have been ejected from the binary system. Hence, since they are still associated, the amount of mass ejected was comparatively small, and, <u>the mass of B has always been less than the mass of A</u>. (The ellipticity of the orbits of the components is only 0.17, signifying a very small mass ejection during the nova stage.) However, it is well known that heavy stars evolve considerably more rapidly than lighter stars, and since we must assume that the two components were formed at the same time, (it is hard to imagine how the components of a binary system could be formed in any other way), we arrive at a paradox. B is older than A, evolution wise that is, but A should be older than B, and we must ask the question, why is A at an earlier stage of evolution than B when it should be the other way round?

Derek Hook recently suggested a solution, that a large protostar might have been formed, gone nova, leaving a remnant that collapsed to form B, and ejecta which later condensed to form A. This is an imaginative suggestion, but I have found, unfortunately, one objection to it. That is; angular momentum would have to be conserved in the system, and so the momentum existing presently as orbital angular momentum would have to have been present in the protostar as rotational angular momnetum, or spin. This would have given the protostar a rather indecently large rotation rate.

Problems with -Aur still remain.

REFERENCES.

1) The story of Epsilon Aurigae.
Otto Struve Sky and Telescope March 1962.

2) Evidence for a collapsar in the binary system ε-Aur.
A. Cameron Nature 229/178/1971

3) Collapsars, infrared disks, and invisible secondaries of massive binary stars.
R. Stothers. Nature 229/180/1971

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

252 COLLEGE STREET TORONTO 2B, ONTARIO

REQUEST FOR PAPERS - 1971 GENERAL ASSEMBLY

As usual, one of the highlights of the 1971 General Assembly in Hamilton (co-hosted by the Hamilton and Niagara Falls Centres) will be the Session for Papers.

Members are invited to contribute by submitting short papers on such topics as historical astronomy, instrumentation, the results of original observational programs, etc. The time allotted to each paper will be 10-12 minutes. Please note:

1. Members attached to Centres must have their paper approved by the Executive or Council of their Centre before submitting the paper in final form.

2. An abstract or summary of the paper (about 150 words) should be sent to:

    Dr. Ernest Seaquist,
    Chairman, Committee for Papers,
    252 College Street,
    Toronto 2-b, Ontario

not later than April 1, 1971. The size of slides you intend to use or any special facilities you may require for demonstrations should be indicated. If you are unable to attend the General Assembly but wish your paper to be read by another member, this should also be stated.

The manuscript of the paper IN FINAL FORM should be forwarded to Dr. Seaquist by APRIL 23, 1971.

The Committee for Papers requests that Officers of Centres draw this notice to the attention of the members of their Centres. Papers from unattached members are, of course, equally welcome. Thank you!

Ernest R. Seaquist,
Chairman,
Committee for Papers.

1 March, 1971.