THE Prairie Astronomer

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President's Message...

We are losing another member: Steve Traudt is headed for Grand Junction. Colorado and new career opportunities. Steve offered us a very nice picnic table for Atlas Site, but I made an executive decision not to accept (although it would have been convenient to have under the trees on one of the former helo pads.)

My decision was based on the recent discovery that the padlock on the gate to the site has disappeared, probably having been removed by trespassers attempting (and succeeding) to gain entry. Because we haven't managed to secure the site, anything we put out there of a permanent nature is a target for vandals. I just couldn't see accepting Steve's generous offer, and then having him come back for a visit to discover that his picnic table had been reduced to kindling by neanderthal cretins. For the same reason, we have to put on hold construction of an outhouse, even though we have found a perfect location for it. Ideas regarding security would be much appreciated.

On the positive side, Ron Veys and I met a representative from Strohmeier's Excavations at the site early this month. He agreed that the access shaft job was not completed as we requested, and said they would make it right. And, Steve Bornemeir and Del Motycka have harrowed and seeded the private pad area. So, progress has been made.

On Sunday evening, October 4, at 6:30 p.m., Hyde Observatory will celebrate its 10th Anniversary with a small, exclusive party for contributors, staff members, volunteers, and city officials. Awards will be made, and recognition for service will be accorded.

The Prairie Astronomy Club has been a prime contributor, both as a service organization, and through its individual members, since the day the observatory was first conceived. As such, I have been instructed to invite any and all members who wish to attend this celebration event. Our corporate charter includes public education as a key purpose for our existence, and we have performed exemplary service at the observatory toward that end. The club, and its dedicated individual members, should take a little time

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to pat ourselves on the back for a job well done.

Although we were a month late last year, please note that the September meeting is when we customarily nominate officers for the new year. Elections are held at the October meeting, and the new officers take their positions then. Come prepared to nominate a new President (I will not be standing for re-election, due to time commitments), and let's have our usual (!) spirited election. See you at the meeting.

Lee Thomas

Is Jupiter Losing Its Red Spot???

by David Knisely

Those of you who have never seen the "Red" spot on Jupiter may want to make it a point to try and see it soon. As of September 10th, I observed it almost buried in the south equatorial belt. It is almost colorless with only a hint of pink on the south edge and seems more stretched out than usual. Downstream from the red spot in the equatorial belt is a very disturbed area consisting of four or five white spots of various sizes bunched together. I do not recall ever seeing the red spot actually existing inside one of the major equatorial belts and I wonder whether it can continue to do so for very long before being either kicked out of the belt or possibly destroyed by the wind currents. It might even absorb some material and turn red again. In any case, it bears watching. The spot should be visible in telescopes six inches and larger at very high power. I used my ten inch f5.6 Newtonian and the Lumicon Deep-Sky filter to observe Jupiter's features. The filter makes the details stand out much better than even the standard blue filters can, revealing small festoons and white spots that are normally lost in the glare of Jupiter's white zones. I have also noted some belt activity in the North Temperate zone that bears some watching. A series of very narrow belts are covering most of the mid and upper latitudes and some even contain a few white spots. So drag out that telescope and start taking a peek at the weird weather on the largest planet in the solar system.

The Prairie Astronomer is published monthly by the Prairie Astronomy Club, Inc., and is free to all club members. Membership status and expiration date is listed on the mailing label. Membership dues are: Junior Members and Newsletter Only Subscribers... $8/yr; Regular Members... $22/yr; Family Membership... $25/yr. Address all membership renewals or questions to THE PRAIRIE ASTRONOMY CLUB, INC., P.O. BOX 80553, LINCOLN, NE 68501. For other club information contact one of the following officers: Lee Thomas (Pres) 483-5639, David Knisely (V.Pres) 1-223-3968, John Lortz (Sec) 1-390-9821, Norma Coufal (Tres) 483-5685, Dan Neville (2nd V.Pres) 476-7772. All newsletter comments and articles should be sent to Newsletter Editor JOHN LORTZ, 9255 CADY AVE #14, OMAHA, NE 68134 no later than 6 days before monthly club meetings. Club meetings are held the last tuesday of each month.

Observing Chairmans Report

by David Knisely

STAR PARTIES FOR OCTOBER ARE SCHEDULED FOR THE 16TH AND 23RD AT THE ATLAS SITE. The biggest planetary nebula in the entire sky, NGC 7293 in Aquarius, is now well placed for viewing. Visible in a pair of 10x50 binoculars, this giant ring is half the size of the full moon and can be located about a degree west of Nu Aquarii. It is difficult to see due to its low surface brightness, so use very low power. A six inch rich-field will show it barely, but if you add the Lumicon UHC or Oxygen III filter, the nebula becomes very easy. Users of eight or ten inch instruments will find that the Oxygen III filter brings out hints of the helical shape in the nebula. Also in Aquarius is the bright globular cluster M2, located just under five degrees north and a half east of Beta. Visible in binoculars as a small faint smudge, the cluster will show many of its stars when viewed in a six inch Newtonian. An eight or ten inch telescope and high power will make the cluster look spectacular.

Those of you who have wondered what a barred spiral galaxy looks like can take a look at NGC 7479 in Pegasus. Located about three degrees south of Alpha, this object appears as a faint diffuse oval in a four inch. An eight inch will show the central bar as a brighter elongated area near the center of the galaxy, and a ten inch will show a hint of one of the two spiral arms when conditions are good. A bit easier galaxy to find is NGC 7331, located just over five degrees north and a degree west of Eta Pegasi. This object should be visible in a 60mm refractor as a small elliptical fuzzy patch with a brighter center. In an eight inch, the galaxy begins to look like M31 does in a small pair of binoculars. A ten inch will show some vague patchy detail and the main dark lane as a marked drop off in brightness along one edge of the galaxy. Large telescope users will also find a few tiny dwarf galaxies scattered around NGC 7331. Also nearby is the famous group of galaxies known as Stephan's Quintet. Located about a degree south and a little west of NGC 7331, this group is small with the brightest three of the galaxies being just within the light grasp of a good eight inch telescope. A ten inch will show all five of the group, but none show any real detail.

Of course, the constellation of Andromeda is most known for the Great Andromeda Galaxy, M31, near Nu Andromedae. I think that large binoculars offer the best views of this galaxy due to its large size. I have seen the major dark lane along the north-west edge of the spiral in a pair of 11x80 binoculars and have seen a hint of it in a pair of 10x50's under good conditions. Also in Andromeda is the famous "Blinking Eye" nebula, NGC 7662. It can be found less than a degree south of the faint star 13 Andromedae and is visible in a 60mm refractor as a star-like object. An eight or ten inch will show it as a fuzzy bluish-green disk with a brighter oval inner shell. I have seen what appears to be the central star near one part of the inner shell, but it may just be a brighter spot in the nebulosity. The use of alternating direct and averted vision makes this object blink in small to moderate sized apertures.

One of the more difficult Messier objects is M33, the great Triangulum spiral, located about three and a half degrees west and one north of Alpha Trianguli. Its listed magnitude of 7.8 makes it seem like an ideal target for beginners with 60mm refractors, but most novices fail to find it unless they use

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very low power. It is easy in binoculars, but is usually unimpressive even in fairly large instruments. A six inch will make it seem mottled and will show the slightly brighter nuclear region, while an eight inch will show some hints of the overall spiral structure. On the north-east edge of the galaxy off the end of a spiral arm is the gaseous nebula NGC 604, which is probably the most distant nebula visible in amateur instruments. It can be seen in a good six inch as a small fuzzy spot of light that doesn't seem to be connected with the galaxy even though it is.

Lumicon's Emission Nebula Filters

by Rick Johnson

Lumicon has revolutionized the amateur's view of emission nebula. They now make 3 different filters for emission nebula. They are the UHC, H-Beta and O III. The problem is which filter or filters should you consider buying. I will try to sort this all out. Note that the Deep Sky filter they also make is not an emission nebula filter. It gives some enhancement to all nebula nd therefore helps some with emission nebula but is best suited for general photography, viewing galaxies and Jupiter's cloud belts.

When viewed visually we see mainly three emission lines emitted by the emission nebulae. They all fall closely together in the blue-green portion of the spectrum. In fact they are separated by only 146 angstroms. When you consider that your night vision (the rods) see across more than 3000 angstroms, these emission lines fall in a very small part of the spectrum. This is where the UHC filter was designed to work. It passes 240 angstroms centered on these emission lines. It takes in more than the lines because, as with any filter, the response of the filter doesn't fall off suddenly but gradually. If the filter were narrowed down much more, one or more of the emission lines would be weakened.

UHC stands for Ultra High Contrast and this describes the filter very well. It greatly increases the contrast between the sky and the nebula. Making nearly invisible nebula beautiful while beautiful ones often become entirely new as seen through the filter. For instance, M-27's short axis without the filter is its long axis with the filter making it look far different.

One of the three emission lines the filter passes is called the H-Beta line while the other two are due to doubly ionized oxygen. The H-Beta line is a weak line due to hydrogen in the nebula. The major hydrogen line is the H-Alpha line in the deep red portion of the spectrum. Unfortunately our dark adapted eyes can barely see this line. In fact we see the H-Beta line much better even though it is far weaker! The UHC filter does pass the H-Alpha line in case you have a telescope large enough to make the nebula bright enough to activate the red portion of your color vision. Most of us don't have such telescopes though maybe Del will let us look through his when it comes.

Since widening the UHC for the H-Beta line as well as the H-Alpha line sometimes adds little to the image, Lumicon has now come out with the O III filter. This filter just looks at the two O III lines and cuts off the nearby H-Beta line as well as the deep red H-Alpha line. This change reduces the band width to only 110 angstroms, more than doubling the contrast of the UHC for oxygen rich nebula. Many diffuse emission nebula like M-8, M-16, M-17, and M-42 are oxygen rich as are most all of the planetary nebula. These objects show a wealth of detail not seen in the UHC filter. But other emission nebula vanish entirely in the filter. These are the California, Horsehead, and Cocoon. I haven't checked others

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out as yet but there are probably more to add to the list. These vanish due to a lack of O III emission. If they have oxygen it isn't doubly ionized. (Before you complain, don't I mean triply ionized, O I is used to designate unionized oxygen!)

Lumicon has yet another filter out called the H-Beta or Horsehead filter. This filter is made for the nebula that are invisible in the O III filter. As you have already guessed it looks only at the H-Beta emission line and cuts off the O III lines. It's bandwidth of 90 angstroms is even narrower than that of the O III since it has to catch only one emission line. It has the highest contrast of all, but is looking by far at the weakest of the three lines. This filter is only good for a few nebula like the Horsehead, but will enhance these over the UHC even more than the O III enhances the other emission nebula over the UHC. Unfortunately the nebula this filter is made for are barely seen in the UHC and even doubling the contrast of the barely seen doesn't add nearly what the O III filter does to already easily seen nebula.

So, which filter should you get? That all depends on what you can afford and what you look at. For general viewing of emission nebula, the UHC is probably still the best choice since it greatly enhances most all such nebula. But if you are a planetary nut (like me) you will want the O III filter. With its narrow bandwidth it will "blink" a field for that 1" of arc planetary much better than the UHC. Don't get me wrong, I have found dozens of starlike planetary with the UHC, it's just that the O III does it better. Also, faint planetary around bright stars are much easier seen with this filter as it cuts the central star's light by at least a magnitude over the UHC and three magnitudes over no filter. Of course if you want to see the nebula with only the H-Beta line then you'll also need the H-Beta filter. For this reason the UHC is still probably the filter to have if you can afford only one. If you can afford two then you can forget the UHC and get the other two... Unless you want the best possible view of all emission nebula, then you need all three! No matter which filters you get, use them as close to a 7mm exit pupil as you can as this is where you will get the maximum gain from the filter. This means a 70mm 2" eyepiece in a Schmidt-Cassegrain, a 56mm 2" eyepiece in a f/8 reflector or a 32mm 1.25" eyepiece in a f/5 reflector.

What if your eyepieces don't take filters, like many at Hyde? You may be in luck. Lumicon makes adapters that do the trick. The 1.25" adapter looks like a short Barolow lens holder. The filter screws in the bottom and the eyepiece slides in the top. It does raise the eyepiece about an inch so you need about one inch more inward focus capability than you presently need. Unless you have mounted your mirror unusually far back in the tube, you probably can make it work. Other wise you may need to more the mirror slightly forward in the tube. For those of you with 2" focusers, they also make a 2" to 1.25" adapter that holds filters (the expensive 48mm kind) that takes up no more back focus than your current adapter already does.

I have a 32mm Plossl by Jager that I have always wanted to try the filters on but have been unable to because there was no room to put a filter on. With the 32mm eyepiece, adapter, and O III filter the Veil nebula is far more spectacular than I have every seen the Orion nebula without a filter. In fact, it is easy to see the intricate veins of nebulosity inside the portions of the nebula BETWEEN the two bright arcs. The contrast resembles that of a good photo printed on #6 paper. That is very high contrast paper, by the way. The nebula is a brilliant blue-green color that shimmers as you look at it. The brighter regions seem "overexposed" as they shine much brighter than any star in the field of view.

Note that these filters are not really "light pollution filters". In fact the better the sky conditions the more they will improve the view! I am amazed how few of our members have any of these filters. When a UHC filter on a 6" reflector will easily show far more detail in M-8 than a 12.5" will without the filter, instead of yearning for that huge 'scope, get a filter or two. It's far cheaper and will open up a whole new sky for you.

Lessions in Astrophotography

Here's the second installment of Greg Beach's informative articles on astrophotography, downloaded from the Compuserve Information Service. By the way, Greg dropped me an electronic letter saying to tell all you prairie folks hi... so "Hi!" [editor]

STARTING OUT - CAMERA BASICS

Any camera can be used for astrophotography. From the simple "instamatic" at a solar eclipse to any camera that has a "B" (bulb) or "T" (time) setting on the camera body or lens for longer exposures. Just about any camera built since its invention over a hundred years ago can be pointed to the stars. Some cameras of course have their limitations.

INSTAMATICS

I mention the instamatic because so many of these cameras have been sold over the years. In all honesty you won't find these with any astrophotographer except perhaps to record a trip to a dark site during the day or a trip abroad for a solar eclipse. Why? These cameras were made to be inexpensive and sell lots of film to Mary, John and the kids for their trip to the zoo. For that purpose alone they are fine. For astrophotography they are not. Most have a fixed lens, meaning non-interchangeable and often permanently focused. This by itself is not bad, but since they are usually small and fit in the palm of your hand the lenses are often plastic and the widest opening (F-STOP) inside the lens is tiny. The feeble light we receive from the stars needs the largest f-stop as is possible. Plastic lenses were introduced because they are easy to mass-produce and cheap. They seem to record a well-lit daylight scene just fine. When it comes to recording tiny points of light on film they end up being big blobs if that light reaches the film at all! That's enough on instamatics. You won't here me mention them again, except perhaps in cannibalizing one for some other project.

35MM CAMERAS

Without these all-purpose cameras, there probably wouldn't be very many astrophotographers around today. They are small enough to tote around in an equipment bag and light enough to add to the "business end" of a telescope. A great range of film is available for them and manufacturers are constantly improving and releasing new film. An abundance of accessories are available for these little wonders too. From filters and screens to tripods and a great range of interchangeable lenses. This is the camera you will want to start out in astrophotography. Today, most people own one or probably know someone who does. There are limitations, some more serious than others. Several models are actually enlarged versions of the "instamatic" family. They are made to take the popular 35mm film but they resemble their smaller cousins more with a fixed lens and shutter. All manufacturers make a similar model and is often the least expensive of their line.

In the mid to late '70's the electronic revolution in cameras had people scrambling for automation and ease of use (and still do today!). In some respects that was a step-backwards for astrophotographers. That Nikon which goes "beep-beep" or Canon AE-1 rely on all its functions by battery power. Unfortunately that includes the shutter. For example, you want to take a ten-minute star trail of Orion. Well, that ten minutes is about all you may get. Since the shutter of some of these models is powered by battery, the entire time the shutter is open that same battery is quickly losing all of its juice! If you're lucky maybe you'll get another ten minutes of Ursa Major but that's all. Once that battery is dead (and you

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didn't bring any spares) the shutter won't open and you pack up and go home frustrated.

Fortunately some models have a manual, mechanical override. This allows you to open the shutter for as long as you desire and the battery is NOT drained. Your camera manual or dealer will tell you if your camera has that capability. I recommend one of these. SLR or RANGEFINDER?

A RANGEFINDER 35mm camera has a little square window (sometimes two) with which you see your subject, frame, then shoot. It can give you a very bright image if you are using it to shoot wide fields of constellations when using the standard lens (35-50mm). Pop a telephoto lens on it though and you won't see the same field in the viewing window as the long lens does. That is the major disadvantage of a Rangefinder. Attach it to your telescope and you cannot see the subject as it appears on the film plane. Most manufacturers make these, LEICA being the most famous.

<S>INGLE <L>ENS <R>EFLEX is the most common 35mm camera (and medium format camera) that you'll find in an astrophotographers equipment bag. When you put your eye to the viewing window you are looking into a prism which is transmitting light from a small mirror inside the camera behind the lens. Therefore what you see in the viewfinder is what the film sees too, no matter what lens or telescope you may have.

When you press the shutter release this action lifts the mirror out of the way and opens the shutter to expose the film. One major drawback is that the mirror is moved very quickly, and SLAPS against the inside of the camera body. During normal photography this creates no problems. Shooting the Moon, Sun or Planets, it can cause great problems! Your camera is attached to your telescope which is really only a very long telephoto lens. Any movement during the exposure, no matter how small, is magnified by the same amount as you are shooting at. All SLR cameras suffer from this dilemma, but OLYMPUS seems to suffer the least.

MEDIUM FORMAT CAMERAS

I'll briefly touch up medium format cameras as I have experience with several of these. They differ greatly from 35mm cameras. Generally boxy in appearance unlike the hand-fitting 35mm. One important difference is film size. Film is 120 or 220 roll film (not cassette) giving you a negative or transparency(slide) of 6cm X 4.5cm, 6 X 6, 6 X 7, 6 X 9, depending on what model you may have. These include BRONICA, MAMIYA, HASSELBLAD, ROLEII to mention a few. Prices do vary but all are VERY expensive and not recommended for a beginning astrophotographer. Some almost cost the same as a small car! Most are SLR's with either a focal plane shutter (similar to most 35mm's) or a leaf shutter --a shutter in the lens instead of at the film plane. One inexpensive solution is the Yashica Mat. It is a TLR: <T>WIN <L>ENS <R>EFLEX. It has two lenses, one for the film and one for the viewing window. It will work great for constellation studies but is limited by a very small range of accessory lenses.

The film in medium format cameras is at least three times larger than 35mm. This results in less enlargement required for a given photo and therefore less grain and more clarity. A wide variety of lenses exist, but again expense is at a premium, often more than $1,000.00 for a single lens. Film availability is similar to 35mm though not as great. All are too heavy to mount on most amateur telescopes except perhaps for "piggybacking". I'll be talking more about these cameras in future articles.

ACCESSORIES

Two accessories you MUST have are a Tripod or some form of support for the camera during a long exposure, and a Cable Release. This short cable attaches to the shutter button of your camera and allows you to lock the shutter open(when set a "B" or "T"). It gives you a smoother release and keeps you from jarring the camera when first opening the shutter and then closing it. A tripod is something you will use for all your photography, not just the night-time variety, so don't skimp in this area.

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MANFROTTO makes a fine, solid tripod.Make sure your cable release has a lock on it (some do not) and you don't needone that is 20 feet long! In fact while your at it, buy two cable releases oreven three – TRUST ME!!

I won't mention filters right now. That is a whole topic by itself. You mightalready have a few lying in the bottom of your camera bag. Don't throw themout. You might be surprised what your regular-photographicfilters can do whenpointed at the night sky.

Equipment bags come in all sorts of shapes, sizes and materials. Buy one youcan afford. If you're just starting out don't go out and buy a super - dupertitanium model! They are bulky and suddenly become VERY heavy when trudgingthrough bush or snow or climbing to the top of the next ridge. Don't buy thesmallest you can find either. You'll quickly fill them and you'll end up havingto spend more money on another one. Get one that has enough room for a camerabody or two, a couple of lens, several rolls of film and a couple of emptypockets for odds and ends or maybe even a sandwich!

FILM

Do you want to shoot colour or black and white? Negatives or slides? That willbe your choice, not mine. We'll be covering this topic indepth at a later timebut here are a few hints for starting up:

BLACK AND WHITE

KODAK TRI-X is an old friend to astrophotographers. It is a relatively fast andfine-grained film at ISO 400 (35mm) and ISO 320 (roll film). ILFORD has somefine B/W films too in similar sizes and speed range as Kodak. Kodak hasrecently announced a new family of B/W films -- TMAX -- I'll report here whendata comes in and experiments are underway.

Youmayhave heard of Kodak Technical Pan 2415. It is an extremely fine-grainedfilm, red-sensitive, but very slow. Graphics artist use it for copying andlandscape photographers use it for penetrating horizon haze. It is an excellentchoice for shooting the Sun (with proper filtration), the Moon, and the Planets.It is too slow for galaxies, nebulae, clusters, etc. However, TP2415 is soversatile you CAN use it for the stars, but as a beginning, "budding"astrophotographer you won't be using it right now.

COLOUR FILM - NEGATIVE:

All colour film can be used to "shoot-the-stars", but the faster the film themore stars recorded. This will limit you to ISO 200 or greater. KODAK VR200,400, 1000 come to mind as do KONICA SR1600, FUJI SHR400, etc. Remember, thefaster the emulsion (film), the grainier the print. To be fussy, a 35mmnegative should not be enlarged any bigger than a 4x5 print or maybe stretchedto 5x7. In reality you'll often find 8x10's and even bigger.

When shooting near cities, towns, or any outdoor lighting the film may have ageneral over-all colour cast. That means the background will not be true blackbut a washed-out colour the same as the outdoor lights, depending upon thesensitivity of the film. This problem applies to both negatives and slides.

COLOUR FILM - POSITIVE:

Instead of Positive you may know it as Slide or Transparency. Manyphotographers prefer shooting slide film. It gives you a positive image and canbe viewed directly, unlike a negative which requires a print to view it. Whenviewing a slide directly, you are seeing a "first generation" image. A print(second generation image) is never as sharp and clear as the negative thatproduced it. Not so with a slide. A slide can also be projected on a screen orwall so many people can see it at the same time. It also has another distinctadvantage - a slide can be printed like a negative and as a result it often hasan increase in contrast which is a plus for the astrophotographer. Some peopleeven convert their negative to a slide BEFORE printing to "catch" the contrastadvantage. We'll do this here too.

Colour slide film comes with names such as the KODAK Ektachrome family - ISO 200and 400 - and the new Kodachrome 200. 3M 1000 is a good fast film and often canbe found with a "department store" brand name on the box, ie. KMART for example.FUJICHROME's make excellent astro-

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photo slides too including the fastest at ISO1600!
PHOTOFINISHERS
These guys can be your BEST friend or your WORST enemy. Their automatedmachines are calibrated for average exposures of daylight scenes of little Suzyat her third birthday party. Your astro-photos, negative or slide, are alien tothem. It's up to you to educate them on your roll of film. As far as they areconcerned your film is under-exposed with little dots and maybe some fog on it. Your treasure, their trash! Find a photofinisher you can rely on and stick withthem. Let them get to know your needs. If possible, shoot at least one averagedaylight scene at the beginning and/or end of each roll of film. This will helpthem calibrate to your roll and to keep them from cutting the film in the middleof the frame.
If you are still concerned, ask them to DEVELOP ONLY and leave the film UNCUT.You can do the rest at home and choose which frames you want printed or mounted.In fact, mounting your own slides is easy! This method may take a bit longerbut it is insurance against misuse and poor handling of your precious film by anuneducated person. It can save money too!
One problem with a photofinisher is it can be difficult at best to find one thatwill develop black & white film - one big reason many do-it-themselves. Everynega-tive or positive, colour or B/W, I shoot is mounted in a slide-mount. Easyto print or work with, easy to label, and easy to file. A good practice toconsider now!
SUMMARY OF OUR LAST THREE SESSIONS
Our last three sessions covered the basic equip-ment that a beginningastrophotographer should have in his equipment bag. Let's summarize:
• 35mm SLR camera with standard lenso Cable release(s)• Tripod or solid supporto Black & White or Colour film - Negative or Positiveo Case to carry above equipment (including pencil and paper for your records)• A Trusting, Educated Photofinish-ero An astro-subject to shoot (game plan)• Clear

NOAO TESTS REVOLUTIONARY DETECTOR...

FROM COMPUSERVE ASTRONOMY NEWS SECTION

TUCSON -- A tiny, superchilled detector now being evaluated at the National Optical Astronomy Obser-vatories (NOAO) is revealing a previously unseen world in the near-infrared, with great swatches of dust, gases, and newly forming stars glowing where nothing had been detected before. For infrared astronomy, the device marks the beginning of a technological revolution comparable to that caused in optical astronomy by the introduction of the pho-tographic plate.

The arrival of the new sensor means that, for the first time, groundbased "infraredders" have tools and techniques that begin to match those of colleagues working the visible spectrum, and a substantially better way to use their precious ration of large-telescope time. Now, instead of painstakingly con-structing infrared maps of the sky by "rastering" -- taking data one point at a time, with the telescope re-aimed for each point -- they can image a patch of sky in a matter of seconds. As one NOAO astronomer put it, "You do what used to be a night's work in a few minutes."

But, besides replacing a single detector with an array of nearly 4000 of them, the instrument employs individual detectors that are as much as 100 times more sensitive than the infrared detectors they replace. This will permit observers to press out toward fainter and fainter infrared-radiating sources, as optical astronomers have with charge-coupled devices, or CCDs, even with relatively small telescopes.

"At the moment," says Dr. Frederick Gillett, an astronomer at NOAO's Kitt Peak National Observa-tory, and project scientist on the infrared-detector

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team, "for many applications at these wavelengths, the 50-inch telescope on Kitt Peak may be the most powerful infrared telescope in the world." He adds, "Of course, on a four-meter-class telescope, it's an altogether new game. You can carry out observations you wouldn't have dreamed of doing in the past."

Infrared astronomy has always been a difficult field because sources of infrared radiation are rarely much stronger – much "brighter" – than their background, so that observing at these wavelengths is often likened to looking for stars at high noon. Instead of having bright points of light against a dark background, the detector must pull faint sources out of a world that glitters with infrared radiation.

"Infrared is an awkward place to look," explains Dr. Ian Gatley, who came to NOAO from UKIRT, the United Kingdom Infrared Telescope on Hawaii's Mauna Kea, to direct the infrared program. "The telescope, the sky, even the observers, radiate in the infrared. When you let that radiation into your instruments to extract the very best information, you need to use narrow band widths and small fields of sky."

The new detector overcomes this by "focusing" on the wavelengths between one and five microns, which mark the region where visible light, at about one micron, shades into near infrared radiation -- a region where the sky changes dramatically over very small changes in wavelength. The array is cryogenically cooled by liquid helium to about 40 Kelvin -- minus 388 degrees Fahrenheit --and, according to Gatley, it is possible to take it down to only 4 Kelvin, close to absolute zero.

The device itself is a "hybrid" array about the size of a flake of confetti, in which the advanced infrared detectors -- a grid of 58 by 62 indium antimonide detectors -- are read out through a conventional silicon microchip. A computer system – the Image Reconstruction and Analysis Facility, or IRAF -- converts the digital signals to images. The detector technology was developed by Santa Barbara Research Center, a subsidiary of Hughes Aircraft Company, for the Department of Defense. As Albert Fowler, NOAO's engineering manager on the project team explains, "The Department of Defense funds state-of-the-art infrared. Astronomy doesn't have that kind of money." But the fact that the technology existed led to an unusual partnership between researchers at NOAO (and other major centers for infrared astronomy) and engineers at Santa Barbara Research Center.

"Santa Barbara decided to market the product to astronomy," Fowler recalls, "partly motivated by work we've been doing with another Hughes subsidiary for three or four years. They saw the potential for a product, and came to us, and asked us to buy in. It was all proven technology. I was very familiar with the chip they were going to put the detectors on, knew what they were going to do, and had confidence in their ability. That's how Santa Barbara was able to bid on this. We all knew the technology."

This joint undertaking of astronomy and industry began several years ago. Following evaluations of early engineering-grade detectors, Santa Barbara Research Center delivered the firs science-grade arrays to NOAO in March, where they were quickly moved toward operational service. Thus far, the detector arrays have been used to obtain images at the 84-and 50-inch telescopes on Kitt Peak. In May, Fowler will travel to Chile to install and begin operations with the second science-grade detector at NOAO's Cerro Tololo Inter-American Observatory. Beyond that, a second pair of detectors is earmarked for infrared spectrometers already built at the observatories. Ultimately, the array-equipped instruments will be used on the 50-, 84-, and 158-inch (4 meter) telescopes at Kitt Peak, and the 50- and 158-inch telescopes at Cerro Tololo.

"We're already taking proposals now for work next semester," says Gatley. "But I'm just the driver. The people here who've developed it, they've shown a tremendous amount of foresight. They've anticipated the array in their instrument designs. Our computer facilities were ready to handle it. When

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we finally got the science-grade array, it worked for the first time. Converging technologies are no accident. It is what national observatories are supposed to be doing." He notes further that making the new infrared detector arrays quickly operational at national centers means they will be available to all of American astronomy. "The revolution," says Gatley, "is upon us."

For infrared astronomers, the arrival of an operational array opens a world many thought might be closed to them forever. "People have thought, 'If I had this kind of array, I could answer this or that question,' " Gillett says. "And to a certain extent they've just filed those problems away because they were so hard to solve. Now, you just dust off those thoughts. You say, 'Now I can answer some of those questions."

Among the astronomical problems being dusted off by infraredders are:

o STAR FORMATION. "In the past," Gillett says, " if we were interested in studying a region where stars were very young objects, just in the process of forming, we had to survey the area one point at a time." While some "famous" star-formation areas have been mapped inthis laboriousway, the technique's appetite for telescope time has been prohibitive. Now astronomers will be able to survey promising areas, using he infrared to probe protostars and the processes of star formation, which appear to be fundamental to the history and fate of the universe.

o EXTRASOLAR PLANETS. One of the insurmountable problems of searching for extrasolar planets and failed stars called brown dwarfts has been that they are dark objects, orbiting invisibly in the glare of their suns. In 1985, a team of astronomers at NOAO and the University of Arizona detected what was believed to be either the first brown dwarf or first extrasolar planet ever discovered; but VB8B, as the object was called, has not been recovered since. Dr. Ronald Probst, one of the co-discoverers of VB8B and an astronomer on NOAO's detector-array project, will make an early attempt to image the elusive object with the new array, as well as similar objects that may be circling nearby stars where circumstellar dust clouds have been indicated. With the new detector, and an occulting device to mask out the brighter host star, Probst hopes to obtain the first infrared images of brown dwarfts and, with any luck at all, Jupiter-sized planets in other solar systems.

o PURSUIT OF REDSHIFT. Because in an expanding universe the light from very distant objects is shifted toward the longer, redder end of the spectrum, "redshipft" provides an indication of both the distance to the object and its speed of recession. But as redshift increases, as in the case of galaxies seen as they were ten billion or so years ago, crucial features in the spectra are shifted out of the visible wavelengths and into the infrared, where ground-based astronomers have been unable to follow. A spectrometer equipped with the new infrared detector array permits hot pursuit of these high redshifts, helping astronomers explore the evolution and age of galaxies, and how these connect to the fate of the universe.

o PLANETARY STUDIES. "The second night we had this array we imaged the ring around Uranus," Gillett says. "It's a very straightforward observation with the infrared array, but extremely difficult in the visible because the planet is relatively so bright." The next steps: the first ground-based imaging of Neptune's rings, and use of the array for infrared measurements of planetary atmospheres."

o GALACTIC EVOLUTION. The detector will help determine whether some irregular galaxies, whose odd shapes are defined mainly by bluer (younger) stars, also have large populations of the cooler, redder, older varieties that have thus far been hidden in the glare of their hot blue neighbors. Since red stars are evolved stars, large mixed populations would show that star formation in such galaxies did not occur all at once, as generally hypothesized, but

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in stages, and over a longer period of time. Moreover, a good look at these irregular galaxies inthe near-infrared could reveal a more conventinal, spiral structure that cannot be seen at other wavelengths. The work holds profound implications for our understanding of galactic evolution.

o THE GALACTIC CENTER. Most astronomers believe the center of our Milky Way holds a complicated structure of some kind -- perhaps a black hole, or active nucleus -- close enough for rather detailed study. But our line of sight to the galactic center is obscured by dust. "Extinction between us and the center is about 30 magnitudes in the visible," explains Dr. Richard Joyce, another Kitt Peak astronomer working on the detector project. "At two microns, extinction is ten times less, only three magnitudes. So we'll be looking through the dust." These unique observations will probably come from an infrared detector at Cerro Tololo, where the center of the galaxy passes overhead.

o EXTENDING IRAS. The new detector offers astronomers an unexpected chance to extend what they ahve obtained from IRAS, the Infrared Astronomical Satellite, which measured infrared radiation from 10 microns out to about 100 microns. Since the area imaged by the detector array covers a single IRAS sensor footprint, the new device provides a means of pulling detail from the less-resolved backdrop provided by IRAS.

As the four science-grade detector arrays begin operation in Arizona and Chile, NOAO will turn to developing similar arrays in the 8- to 20-micron range -- the sol-called 10-micron infrared window in the atmosphere -- which, according to Fowler, "will give us all the reasonable windows you can do from the ground." Beyond about 20 microns, where the atmosphere is mostly opaque to infrared radiation, will be the province of the proposed Space Infrared Telescope Facility (SIRTF)

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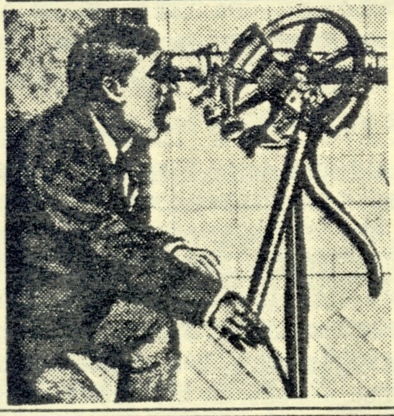

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