The Refractor

The Bulletin of the Eastbay Astronomical Society

Founded in 1924 at Chabot Observatory, Oakland, California

Volume 70 · Number 10 · June 1994

Airborne Telescopes: Their Place In An Astronomer's Toolbox

4 June, 7:30 p.m.
Chabot Administration Building
4917 Mountain Boulevard, Oakland

Dinner with the speaker 5:30 p.m. at
Eve's Hunan Restaurant, 5620 College Ave.
($^{1}/_{2}$ block south of Rockridge BART)
For information or reservations call
Betty Neall at (510) 533-2394

Carl Gillespie, Jr.

Senior Mission Director
Kuiper Airborne Observatory

Carl Gillespie, Jr. was born, raised and educated in Iowa, eventually earning a degree in Agronomy from Iowa State University. He served as a Communications & Electronics Officer in the Air force during the Korean war. He then worked for Collins Radio Company as a Field Service Engineering Supervisor emphasizing problems of Tropospheric Scatter in radio communications equipment. Later he spent five years as an Administrative Assistant. to the Director - Lunar and Planetary Laboratory, University of Arizona where he served as the Director's Liaison to the architect on design of the Space Sciences Building. he also coordinated the installation of the first test telescope on Mauna Kea, Hawaii .

For the next five years he served as Program Manager at the Space Science Dept., Rice University, Houston, Texas. under the direction of Professor Frank Low on the design, fabrication, and use of the Flying Infrared Telescope for use in a Learjet. (The original 1968 Learjet is now at the Air and Space Museum, Washington, D.C.)

He has been working at the Kuiper Airborne Observatory (KAO) for the last 20 years where he is Senior Mission Director. Carl has logged more than 1,500,000 flight miles on the KAO. (This is equivalent to 60 times around the Earth, more than some of the NASA astronauts.)

A widower with two grown daughters, he makes his home in Palo Alto, and is active in community affairs through his church and as a board member of the Children's Theatre of Palo Alto. He likes hiking, and camping and especially enjoys visiting and exploring our national parks.

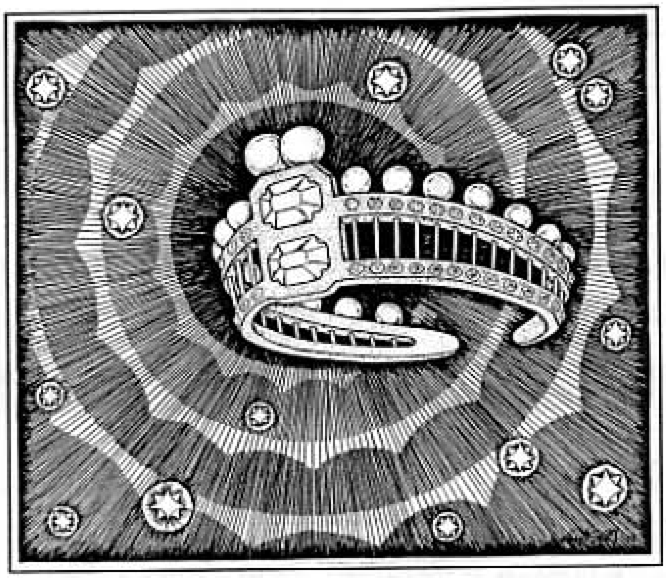
Carl notes that telescopes mounted on high altitude airplane platforms offer the advantage of being above 99% of the Earth's water vapor, which is a must for successful infrared observations. They also offer unparalleled mobility for observation of stellar occultation by solar system objects, andto be above the cloud cover for those rare "once-in-a-lifetime events."

He further intends to review thirty years in the evolution of the instrumentation and telescopes emphasizing the KAO, and will give us a peek at the future of airborne observatories with a look at SOFIA: Stratospheric Observatory for Infrared Astronomy. His talk will include a 25 minute VHS video of the "Queen."

Welcome new Members

The EAS would like to welcome the following who bring our membership to 197:

- George Alpi, Bay Pointe
- Bill Budge, Piedmont
- Ira Stein, Oakland
- Bob Becton, Larkspur
- Celeste Burrows, Emeryville



For Your Eyes Only

One of the prettiest constellations of the summer sky lies to the north and west of Arcturus, between Bootes and Hercules. It is the Northern Crown, Corona Borealis. In early Greek times it was a wreath, but over time it became mythologically associated with Ariadne and became her crown. Daughter of Minos, King of Crete, Ariadne married Theseus after he had slain the Minotaur. The goddess Venus presented her with the crown, but the couple apparently did not live happily ever after. When Ariadne was deserted by Theseus, she changed her name to Libera. When she later married Bacchus her crown was placed in the sky as Corona. Borealis–northern–was added later.

Other cultures recognized this star grouping as well: Australian bushmen looked upon it as a boomerang. Arabians thought of it as a dish; to the Chinese it was a string. The Pawnee depicted the circle of stars to be their Council of the Chiefs, in the sky to watch over the people. In turn, the Council of Chiefs were watched over by Tirawahat, their god "The Star That Does Not Walk Around", who reigned in the north.

The brightest star in the constellation is Gemma, the Pearl of the Crown, at magnitude 2.3. It is also known by the Arabic name Alphecca, the bright one. Beta Coronae Borealis, next counterclockwise from Gemma, is Nusakan.

There are some double stars in Corona Borealis that can be found; and there are two variable stars that are worthy of note. Zeta is a greenish pair separated by 6 arcseconds with components at magnitudes 5 and 6; Eta has a separation of close to 1 arcsecond with magnitudes 5.6 and 5.9.

The irregular variable R Coronae Borealis, lying within the bowl, is an object for binocular interest. Most of the time this star is at its maximum brightness about magnitude 6; then on occasion it will drop quickly to near obscurity at magnitude 12. Unpredictably, it may then recover promptly, or may not return to normal for several years. Probably the best theory for these variations involves ejection of clouds of carbon that obscure the light until the material is reabsorbed or blown away.

The Blaze Star, T Coronae Borealis, is another curiosity, a recurrent nova which acts somewhat the opposite of R. Normally a tenth magnitude insignificant pinpoint, twice in the last 150 years (in 1866 and 1946) it has suddenly flared to almost second magnitude in a matter of hours. The blaze lasts about 20 days. If this is a regular happening, it may flare up again in 2026–watch for it!

Trickling Through the Hourglass II

By Nancy Cox

In the May *Refractor*, I gave a summary of how I began to analyze the data from my experiment aboard the Hubble Space Telescope late last year. Now, for a little about the specifics of my proposal, and the preliminary results:

My proposal was to take a UV spectrum of an H II region (M8, the Lagoon Nebula). H II regions are giant clouds of glowing gas and dust, out of which stars are being born–specifically O-type stars, the very massive hot ones. The H refers to Hydrogen, which makes up 90% of the universe, the II to the fact it's ionized. Since these are regions where star formation is taking place, studies of them are significant, because the early stages of star formation are largely theoretical–they haven't been seen yet. There are many questions: what triggers it, what goes on in the process?

Studies of the nebular gas are important because they are samples of the interstellar matter out of which stars are being born. The O stars radiate strongly in the ultraviolet (produced by bodies above 30,000°K). This radiation from these hot stars ionizes the surrounding gas, stripping the atoms of their outer electrons. When the highly excited atoms settle back into their more stable states, they emit photons of various wavelengths, including the UV. We can thus utilize the radiation from the O stars to study the gas, made hot enough to produce emission lines (like a cosmic neon sign!).

Spectroscopy is an amazing astronomical tool. The chemical elements–ions, atoms, and molecules–can be identified by the wavelengths of their spectral lines. A wavelength is equivalent to a color; red is a certain wavelength; blue is a shorter wavelength. It's the same principle for the other parts of the electromagnetic spectrum. With the ultraviolet, shorter in wavelength than optical and more energetic, the difference is we can't see it with our eyes, but instruments like the spectrographs aboard the Hubble Space Telescope can. They produce a graph-like readout of the spectrum, with the spectral lines as spikes up (emission) or down (absorption). UV cannot be studied from the ground, since Earth's atmosphere absorbs it (except for a few pesky ozone holes!). But orbiting above Earth's atmosphere the Hubble Telescope can do the job.

I chose the Lagoon Nebula (4500 light years away), because the Orion Nebula (M42), the closest and brightest H II region (1500 light years distant) has been the most studied. So, with Hubble's capabilities, why not try some of the other bright, close H II regions? Despite the mirror problem, HST has discovered many stunning new details in such objects. M8, in the summertime constellation Sagittarius, lies in the direction of the galactic center, at the edge of a giant molecular cloud.

HST has much more light gathering power, with its eight-foot diameter mirror, than its predecessor satellite, the IUE (International Ultraviolet Explorer), with only a 1½-foot mirror, and so HST can resolve many more spectral lines. We can expect to gain even more information about the chemical contents of these star-forming regions.

This proposal concentrated on one small area of the Lagoon Nebula: the Hourglass region, the brightest part of the nebula, on its west side. HST's field of view is very small and cannot take in the whole nebula, which is huge, 30 to 100 light years across (at its greatest extent). The Hourglass alone is ½ light year across. Distance to Pluto is 8 light hours, so these regions are very large and complex.

The UV spectrum was taken by the Faint Object Spectrograph (FOS) of the north lobe of the Hourglass. The Hourglass has a bipolar appearance. The first three days of my Baltimore visit were spent taking a look at this spectrum.

The UV region of the spectrum runs from about 1000 to 3000 angstroms (Å). The HST does not get this all in one piece: three different gratings, each with a different exposure, are required to get a complete UV spectrum.

The ultraviolet is interesting because many atoms have their resonance lines in the UV, and are unobservable at other wavelengths. From laboratory studies, many UV emission lines can be predicted, as well as having in mind the typical spectrum of an H II region. Of the hundreds of UV emission lines, only about ten or so are typically found in H II regions, as these regions are very dusty, and so it is much harder to get strong emission lines. You also have to get in close to the ionizing source, as the hydrogen gas rapidly absorbs the UV radiation.

So the first task was to look for some of the known lines, mostly produced by the lighter elements, such as ions of carbon, oxygen and magnesium.

The first looks at the spectra are qualitative; more exact measuring of line strengths needs to be done later. Each "piece" of the spectrum is called up separately on the computer. These sets covered the wavelengths 1100 to 1600 Å, 1600 to 2200 Å and 2250 to 3200 Å. At first it looked discouraging. A factor called "signal-to-noise" ratio comes into play. The spectrum looked so noisy that we didn't expect to see many lines. But the more we looked, the more we saw.

At the computer, first the lines have to be separated from the continuum. This background thermal radiation forms a noisy baseline, while the nebular gas itself is fairly hot at around 8000°K, greater than the 6000°K surface of the Sun, for example. Although if too much of the noise is removed some of the faint data may be lost, the computer is able to perform a "boxcar smoothing" of the baseline, after which the lines can be more easily seen.

These first looks at the UV spectrum of the Hourglass region of M8 were encouraging. Some of the predicted lines typical of those found in H II regions were seen: lines of carbon, oxygen and magnesium. In emission: C III at 1907 and 1909 Å; a large C II spike at 2325 Å; a large spike of O II at 2470 Å; and in absorption C IV at 1550 Å. Also there is the possible spectral signature of a hot young star embedded in the nebular gas shown by a Mg II line at 2800 Å with an absorption and an emission feature. (More on this a little later.)

Carbon lines can be indicative of winds from hot young stars, and studies of gaseous phase carbon abundances can only be done from UV information–there are no carbon lines in the optical range. The cosmic recycling of carbon is very important, as carbon goes into making organic matter, such as us!

Terms such as C II refer to the degree of ionization of the element. H I is neutral or non-ionized hydrogen, H II is ionized hydrogen. Subsequently, in a continuing effort for confusing scientific nomenclature, C II is singly ionized carbon (one electron removed), C III is doubly ionized carbon, *etc.*

Now, you have to be very careful to rule out spurious effects or artifacts before you call them "emission lines" (or absorption lines) from your object. A huge broad spike at the hydrogen 1216 Å spot is the geosynchronous hydrogen emission surrounding the Earth. Hydrogen in Earth's atmosphere extends to 200 to 300 km, well beyond the orbit of the Hubble. You have to check carefully any memos from STScI concerning the status of the instrumentation. In my spectrum, a "bump" at 1400 Å was due to a "dead diode". They had a careful list of such things which might have affected your data on the dates they were taken.

At the computer, by mid-week, I was able to make exact measurements of the wavelengths of the lines. During the rest of the week, as regards the spectra, there was only time to measure the "equivalent widths" of each line–the broadening of the lines. This is a rough measure of the strengths of the lines, although there are many causes.

I'll have to return to STScI for one more visit, for more exact measurements of the lines, such as the line strengths and absolute fluxes. This is important because all during the week Paul emphasized the importance of getting *science* out of the data. This means exact measurements, not just qualitative looks, and mathematical calculations with the data to come to some scientific conclusions with the study. STScI is available for any help reducing data on the computer, but the scientific analysis must be done by the Principal Investigator, perhaps with a collaborator.

The Planets in June

Mercury	Gemini	Evening sky early June
Venus	Gemini-Cancer	Evening sky
Mars	Aries-Taurus	Morning sky
Jupiter	Virgo-Libra	All night
Saturn	Aquarius	Rises about 2 a.m.
Uranus	Sagittarius	After midnight
Neptune	Sagittarius	After midnight
Pluto	Libra	All night

One thing I'd be very interested in is finding the abundances of the chemical elements in this nebula. What's in the "juice" going in to making new stars. As I've mentioned, there are many carbon lines found in the ultraviolet. One 1987 IUE study of the Orion nebula was identified as "the first published results of gaseous phase carbon abundance in an H II region".

For abundances, you need to obtain line ratios (the ratio of the line of one element to another). From these you derive the abundances. This requires a great amount of mathematical calculation.

STScI will fund a trip for the amateur to consult with an expert in their field. For me, that is Dr. Reginald J. Dufour, an active researcher on H II regions, who has made extensive studies of them in the UV using IUE, and who teaches and works at Rice University in Houston, Texas. While at STScI, each guest observer is issued a temporary office. It turned out that my office mate was Dr. Don Walter, a post-doc and colleague of Dr. Dufour. Dr. Walter was there working on FOS spectra of the Orion nebula for the Rice group. It is a distinct privilege to be establishing an astronomy network!

Even with HST's mirror problem, new discoveries and detail never before seen have been found in similar objects; and I had every faith that HST could do the same with the Lagoon nebula. The field of view is very small and does not take in the whole nebula. Just the small Hourglass region (approximately 30 × 17 arc seconds) was imaged. The Hourglass is the brightest part of the Lagoon nebula and can be easily seen in an amateur telescope. As my proposal stated, this study was looking for newborn stars and filamentary detail never before seen. In the literature, most researchers attribute the nearby extremely young O star Herschel 36 as the source of the ionization of the Hourglass feature. But is this so? Might there not be some new young stars embedded in the Hourglass? Ground based studies show several infrared (IR) sources in the Hourglass. This is what I could hardly wait to find out! These regions are extremely complex.

The first looks at the raw images don't tell you very much; they look vague and foggy. Much computer processing is required to bring out the detail. And the observational data are peppered with cosmic rays! These intergalactic interlopers pelt the instruments every 1-2 seconds–a real reminder that the telescope is in space.

My images were taken in two different optical wavelengths–in the light of two different atoms (ions), using narrow bandpass filters: in the light of Hα (the hydrogen alpha line at 6565 Å, the reddish color we are used to seeing in H II region nebula photos); and in the light of S II (sulfur ion, 6373 Å), requiring an even longer exposure, 600 seconds, and therefore accumulating even more cosmic rays.

So, the first task of the imaging was to remove these cosmic rays. If they are not removed, later on during the image processing, they can apppear star-like and fool you into thinking they are part of your object. A standard program removes most of them. They have a characteristic brightness and elongated shape. The rest have to be removed by hand at the computer.

The Hubble Space Telescope doesn't use film, but rather the instruments are CCDs, with many electronic pixels, like a TV or video camera. The WF/PC is made up of four CCD chips, with 800 × 800 pixels each. The actual image processing involves "deconvolution" and the "point spread function" (PSF). The PSF relates to bringing the light (photons), as much as possible to within a small circle or central point. Every telescope or instrument has an individual PSF. Even a perfect mirror would have a PSF (referring to the spreading of the light). This is because of the physics of light itself, the wave nature of light and the nature of matter itself. The spherical aberration of the HST's mirror makes the PSF an even larger and more important problem, but, with the magic of computer programming, they have been able to duplicate the exact pattern from the mirror that appears in each image in order to minimize the problem. This is where deconvolution comes in. It's like taking the darts on a dartboard and bringing them into the center, the darts being the photons. This is where the power of the work station comes in. The many thousands of pixels in each image are run through the alpha program or "iterations" several times–this is after each image was first broken down into four or more smaller parts, with each taking more than 20 minutes for even the computer to run throught it–to arrive at a more detailed, cleaned-up image. After taking two days to do both images, out came color copies of the most detailed images yet seen of the Hourglass region of M8! No young stars immediately pop out but there are several bright areas (including the north lobe where the spectroscopy was done), knots of gas, and complex filamentary detail. One very interesting task remains to be done: to check back in the records and get the exact coordinates of where the FOS spectroscopy of the north lobe was done, to locate exactly where on the WF/PC images the spectrum was taken. Perhaps there may be a young star embedded there that might account for that magnesium line–the literature does indicate an IR source in the north lobe.

During the week I attended a colloquia session where the topic was *The Formation of OB Star Associations*, by Dr. Catherine Garmany of the University of Colorado. The point was made that obviously star formation is going on in these H II regions, but the early stages of it have not yet been seen. She was most excited about my data, and made many helpful comments. I was privileged to go along to a dinner with the speaker, and it was a thrill to spend an evening conversing with the staff scintists, while dining on Maryland crab cakes.

My contact scientist during this visit was Dr. Ron Allen, head of the SCARS division (Science Computing and Research), and also a researcher on H II regions. Words can't describe the excitement of this week, being in such company, hanging out with these scientists for a week. With the HST repair mission just completed the entire staff was so excited and energized. A researcher, Dr. Nino Pangina, whom I'd met at a previous conference in Madison, Wisconsin, presented me with a souvenir button commemorating the "1st HST Servicing Mission". At the Friday Instruments Status meeting it was disclosed that initial testing of the instruments appeared to be going well. Each instrument has to be turned on in the proper sequence and at the right temperature. I was introduced as one of the visitors to the Institute for that week and they took great delight in the fact that I work as a psychiatric nurse–they needed a little "stress reduction" after the repair mission!

Through the week, I had visitors to the computer room to take a look at my spectra and images, staff members who had helped with the initial preparation of the proposal during my first visit in 1992: Ray Villard, from the Public Affairs office, who liked the photogenic nebula images; Ken Anderson, my TA, who had entered the proposal into the computer data base with all the technical specifications; John MacKenty, WF/PC Senior Instrument Scientist, who had given imaging advice last year; and Dr. Laura Danly, my scientific advisor, who had helped with the scientific goals and the time plan of the proposal. She was most delighted and thought the images and spectra looked beautiful!

Needless to say, this was one of the most exciting weeks of my life! The whole process of winning and carrying out an HST proposal has been one of the most interesting and exciting things ever for me. For someone who has always dreamed of doing scientific research to get to do some real research about astronomy using the Hubble Space Telescope is just awesome! I am most grateful for the opportunity to be in such a place. I have thoroughly enjoyed being at the Space Telescope Science Institute and I have thoroughly enjoyed this entire experience.

This has been a fascinating peek into the world of professional astronomy. I learned a lot about reducing and analyzing data, and what goes into doing scientific research. A lot of these first phases of data reduction involves "getting the instrument out of the data". For me, this week was an important first lesson at the computer and learning how to read and display HST data tapes.

Now the next steps in the proposal process will include: 1. One more visit to STScI for more work on the data; 2. Scientific analysis of the data, doing the required mathematical calculations; and 3. Preparation for publication of the results in a scientific journal.

I spent the last two days of my visit in STScI's excellent astrophysical library to find and copy useful reference articles. I returned home Sunday evening, December 19, 1993, several quantum leaps higher, my suitcases loaded down with preliminary spectra and images of M8.

Articles and photographs are welcomed for inclusion in *The Refractor*. Deadline for the July issue of *The Refractor* is June 15, 1994. Items may be submitted by mail to the editor, Ellis Myers, 215 Calle La Mesa, Moraga, CA 94556. Files on disk should be ASCII PC format, for 3.5-inch 1.4M or 5.25-inch 360k. Internet e-mail address is emyers@crl.com. For further information please call (510) 284-4103.

DATELINE JUNE

26 1730 Charles Messier, born
29 1868 George Ellery Hale, born, founder of Yerkes, Mt. Wilson and Palomar Observatories
1 1888 Lick Observatory dedicated
30 1908 Tunguska meteorite struck, Siberia
3 1948 Hale 200-inch telescope dedicated, Palomar Observatory
16 1963 Soviet Vostok 6, Valentina Tereshkova, first woman in space
18 1983 First American woman in space, Sally Ride, Challenger

9 1994 New Moon, 01:26 PDT = 08:26 UT
16 1994 First Quarter Moon, 12:56 PDT = 19:56 UT
21 1994 Summer solstice, 07:48 PDT = 14:48 UT
23 1994 Full Moon, 04:33 PDT = 11:33 UT
30 1994 Last Quarter Moon, 12:31 PDT = 19:31 UT

UPCOMING EVENTS

3-5 June. Festival at the Lake

4 June. EAS Lecture. Twenty-five Years of Airborne Astronomy: KAO and Sofia. Carl Gillespie.

10 June. EAS Board Meeting. All welcome.

25-30 June. Astronomical Society of the Pacific Meeting, Flagstaff, Arizona

9 July. EAS Lecture. Pholus and the Kuiper Belt Planetesimals. Dr. Dale Cruikshank.

16-22 July. Expected impact of Comet Shoemaker-Levy 9 on Jupiter.

3 November. Total solar eclipse. South America.

17 November. Penumbral lunar eclipse.

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