Looking under the lampposts: infrared astronomy in the 1970s

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It is a great honor for me to give the first talk at this celebration for Eric Becklin. He, together with Gerry Neugebauer, had more influence on my career as an astronomer than anyone else, and I’d like to spend a few minutes taking you back to the time when the two of them, together with some other pioneers, notably at University of Arizona, were inventing the subject of modern infrared astronomy.

I apologize in advance for any errors or omissions, particularly if I don’t mention all the right names; this is the first history paper I’ve written since I left high school.

The pre-Becklin Era
While it may be hard to agree on the exact starting date of modern infrared astronomy, it is easy to chronicle when the era of prehistoric infrared astronomy ended. It was January 1st 1966. On that day Harold Johnson, of University of Arizona, completed his literature survey for his an Annual Review article called “Astronomical Measurements in the Infrared”. This paper (Johnson 1966) was a splendid summary of the state of the art on subjects such as star colors, filter bands, and flux calibration, but I see it as the pinnacle of the era when infrared astronomy meant extending visible astronomy to longer wavelengths rather than looking for something new.

On rereading it I noticed a couple of curiosities. First, despite its title, it is focused entirely on stars. Johnson does not even include his own work on M31 or on interstellar dust. Second, it contains the statement: “…it is now plain that probably 75 per cent of the astronomical infrared data that we would like to have can be obtained from good ground-based observing sites”. So much for IRAS and Spitzer.

However there is just a hint of the future on the last page, where the first results from the Caltech 2.2 μm sky survey are mentioned, namely the extremely red stars NML Cyg and NML Tau whose properties had just been published by Neugebauer, Martz and Leighton (1965).
1966-1971

At the time that Johnson’s review article came out Eric was a graduate student working with Gerry Neugebauer at Caltech. What was particularly interesting about the Caltech group at this time was their two-pronged approach. Neugebauer and Leighton had built the 62-inch epoxy telescope and, with Eric’s assistance, were completing their famous survey of the whole northern sky down to third magnitude at 2.2 μm. But they were simultaneously constructing photometers and detector systems that could be mounted on the Mount Wilson and, later, Palomar telescopes. These photometers had smaller apertures, could be more accurately pointed and could measure much fainter objects at several more wavelengths than could the 62-inch telescope. These photometers gave the Caltech group to explore a whole new range of object, and even a cursory look at the titles of the papers that emerged at this time hints at the exhilaration Eric and Gerry must have felt. They were the kids in the toyshop – their toyshop was the infrared Universe.

In the two year period from February 1966 to February 1968 Eric submitted six co-authored papers to Astrophysical Journal that covered more or less every field of astronomy:

- His first refereed paper was with Jim Westphal on comet Ikeya-Seki, which was observed at the Mount Wilson 24-inch out to 10 μm (Becklin & Westphal 1966). This paper elegantly described the heating and cooling of the dust in the comet as it approached and receded from the Sun.

- A couple of months later he was co-author on the second paper to emerge from the 62-inch survey, in which Ulrich et al (1966) described the properties of a dozen stars hitherto boring stars which had strong infrared excesses.

- In September 1966 Eric and Gerry submitted their famous paper on the “BN” object in Orion, based on scans of the Orion Nebula using the Mount Wilson 60-inch telescope (Becklin & Neugebauer 1967). This paper, which introduced the world to the idea of infrared protostars demonstrated forever that infrared astronomy could make fundamental discoveries all on its own.

- The longest paper in this group, and the subject of Eric’s PhD dissertation, was a major work on the Galactic Center - Becklin & Neugebauer, 1968. This was not a “quickie” discovery paper, but a careful and detailed study of the region that modeled the stellar distribution, compared our galaxy with M31 and estimated the visual extinction to the galactic center as 25 mags – a number that has barely been improved on to this day.

- Eric and Gerry proved they could work with their colleagues in the Caltech astronomy department by observing a couple of Zwicky compact galaxies with the 200-inch telescope (Oke et al 1967).
Finally Eric showed that he could also work with infrared astronomers at other institutions – in this case University of Arizona - as demonstrated by the paper on the infrared emission from the Crab Nebula submitted in February 1968 (Becklin & Kleinmann).

Over the next three years Eric and Gerry broadened their range of interests to include almost all the fashionable objects in the late 20th century universe. They observed Sco X-1, M31, Centaurus A, NGC 4151, BL Lac, and the Crab pulsar, as well a bunch of quasars and a couple of M dwarfs. They also, of course, looked at lots of very red stars, with Jay Frogel and Harry Hyland both of whom also worked with the Caltech infrared group at this time. This period culminated in an Annual Review article by Neugebauer, Becklin, and Hyland (1971).

My time at Caltech
During this time Eric and Gerry also published a short BAAS abstract with Ted Hilgemann reporting the discovery of infrared emission in the vicinity of the OH masers in W51 (Neugebauer et al. 1969). This paper caught my eye, and was a major reason why I wrote to Gerry asking if I could join his group as a postdoc. At that time I was finishing my PhD in radio astronomy in Cambridge and, having recently heard the infrared gospel preached there by Jim Ring, decided that what I needed was a change in wavelength.

I arrived at Caltech in Fall 1971 just as Eric was returning from a one-year post-doc at CfA. I fitted in well into the IR group, partly because of Eric and Gerry’s friendliness, but also, I think, because they still thought of themselves as physicists rather than astronomers. I came from Martin Ryle’s radio astronomy group where traditional astronomers, whether they be theorists or telescope-gazers, were treated with scorn and were to be avoided at all costs. I had no formal education in optical astronomy: I had never calculated a model atmosphere or observing with anything larger than a 6-inch telescope. I don’t know if Eric or Gerry have ever calculated a model atmosphere, but they certainly never let it spoil our relationship anyway.

I shared an office with Eric for my two years at Caltech and decided to focus my attention on the compact HII regions I had been mapping with the One Mile Telescope for my PhD thesis.

Let us remember the limitations of infrared astronomy at this time. Infrared arrays did not exist, so that any searching or mapping had to be performed with a single element photometer and a strip chart. Since telescopes were not computer controlled, the rastering had to be done by hand, and since all measurements were made with a small chopper throw, all scans had to deconvolved manually. As a result, only tiny regions could be mapped in a reasonable time, and we had to maximize our chances of detecting an infrared signal. Like the proverbial drunk searching for his keys, we therefore looked under the lampposts where we expected the warm dust to be. The fun was choosing the lampposts that would best guide us to the interesting infrared sources.

Compact HII regions turned out to be very productive because their sizes, a few tens of seconds of arc, corresponded well to the resolution of the Mount Wilson and Palomar telescopes, and because they were rich in infrared phenomena. This illustration from Wynn-Williams, Becklin & Neugebauer (1972) shows the result of scanning about two square arc minutes of an obscured region of one of these HII regions, W3, whose free-free emission I had mapped at 6cm in Cambridge. We see

- An obscured O star, IRS2, heating the HII region at 2.2 μm
- Emission from the ionized gas itself at 2.2 μm, but at a much lower level than predicted from the radio emission. This led us to deduce that part of the source lay behind more than 50 magnitudes of visual extinction. This corresponded to the
largest interstellar column density ever measured up to this time; remember that this was before the discovery of giant molecular clouds.

- Emission at 20 μm from hot dust associated with the ionized gas, heated by absorption of Lyman alpha radiation.
- A compact source, IRS5 which corresponded to an H$_2$O maser source but was not an HII region. Its color temperature of 350 K and a luminosity of $3 \times 10^4$ L$_{\odot}$ suggested to us that it was a massive protostar. It made the Guinness Book of Records as the biggest star in the Galaxy, which was not a claim we ever made.

We got photographed for Time magazine, but the story was scheduled for the same week that the first prisoners of war were released from Vietnam, and never made it into press.

**The mid-1970s**

I returned to Cambridge in Fall of 1973 to take up a faculty position in the radio astronomy group, but my main enthusiasm remained infrared astronomy, and I spent each of the next four summers at Caltech. In all, I wrote a dozen papers on HII regions with Eric and Gerry and a dozen papers on all sorts of other objects.

This was interstellar matter’s finest hour; our work perfectly complemented the avalanche of papers on molecular line astronomy that was beginning to appear, and with the longer wave infrared studies at first from places like Arizona and UCL and a little later from the Caltech group when Mike Werner joined it. We also dipped our toes into spectroscopy with a K-band CVF filter and started to study the atomic and molecular hydrogen lines from HII regions and the shocked gas associated with them.

By this time the word was getting around about infrared astronomy. I remember being interrogated by a US immigration official in New York one summer:

"Where are you going?"
"Pasadena, California"

"Why"
"Scientific research"

"What kind of science?"
"Astronomy"

"What kind of astronomy?"
"Er… infrared astronomy"

"Hey, you mean like Herbig-Haro objects? Welcome to the USA!"
Eric moves to Hawaii

I was in Eric’s office at Caltech in 1976 when John Jefferies called him up to offer him the directorship of the IRTF. I don’t think there was ever much doubt that he would take the job and he moved to Hawaii in 1977. Very soon after that, Eric lured me to a faculty position in Hawaii where I spent many more happy years searching under lampposts with him -- and occasionally hanging on to them.

I will stop my story here except to mention the first paper that Eric and I published from Hawaii because it exemplifies Eric’s approach to astronomy (Becklin and Wynn-Williams, 1979). We were at Hale Pohaku one evening, about to go the summit of Mauna Kea, when we saw the first Voyager photograph of Jupiter’s ring on the evening TV news. The ring had never been observed from the ground because the scattered light from Jupiter is so strong, but Eric immediately remembered that methane absorption in Jupiter’s atmosphere reduces the surface brightness of the planet by a factor of about 30 at 2.2 μm; this was therefore the wavelength to use if one was ever to detect the ring from the ground.

Since we had a K-band system on the telescope on that run, we put aside our planned observations and spent much of the next three nights carefully trying to separate the emission from the ring from the still considerable scattered light component from Jupiter itself and from various Jovian satellites that cruised in and out of our field of view. We eventually succeeded and were able to estimate that the number of particles in Jupiter’s ring is of order $10^5$ times less than in Saturn’s.

What made this observation such a success was

- First, Eric’s insight that this could be done,
- Second, his meticulous experimental technique and
- Third, his philosophical conviction that infrared astronomy is supposed to be fun.

Conclusion

Eric: Happy Birthday!

Thank you for everything you have done for me, and thank you for everything you have done for infrared astronomy.
References


Gareth Wynn-Williams, Eric Becklin, Susan Kleinmann at Mauna Kea. 1978
Addendum: After-dinner anecdote at Becklinfest, April 1 2005

We’ve heard a lot about Eric’s many Observational Firsts in the field of astronomy, but not everyone here knows that Eric is also responsible for a major Observational First in the field of terrestrial geology.

One clear night in 1983 Eric and I were at Mauna Kea, observing galaxies on UKIRT. Eric announced that he was going outside to take a leak, and did so. A couple of minutes later the door flew open and Eric burst in with the immortal words, “Holy shit! Mauna Loa is erupting!”

It was, and it continued to do so for several weeks, for a while threatening the city of Hilo. And as far as anyone can tell, Eric was the first person on the planet to observe it happening.