

*Thirty-eight years of Adventures in  
Observational Star Formation with  
Hans Zinnecker*

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Wonders of Star Formation  
Edinburgh, Scotland  
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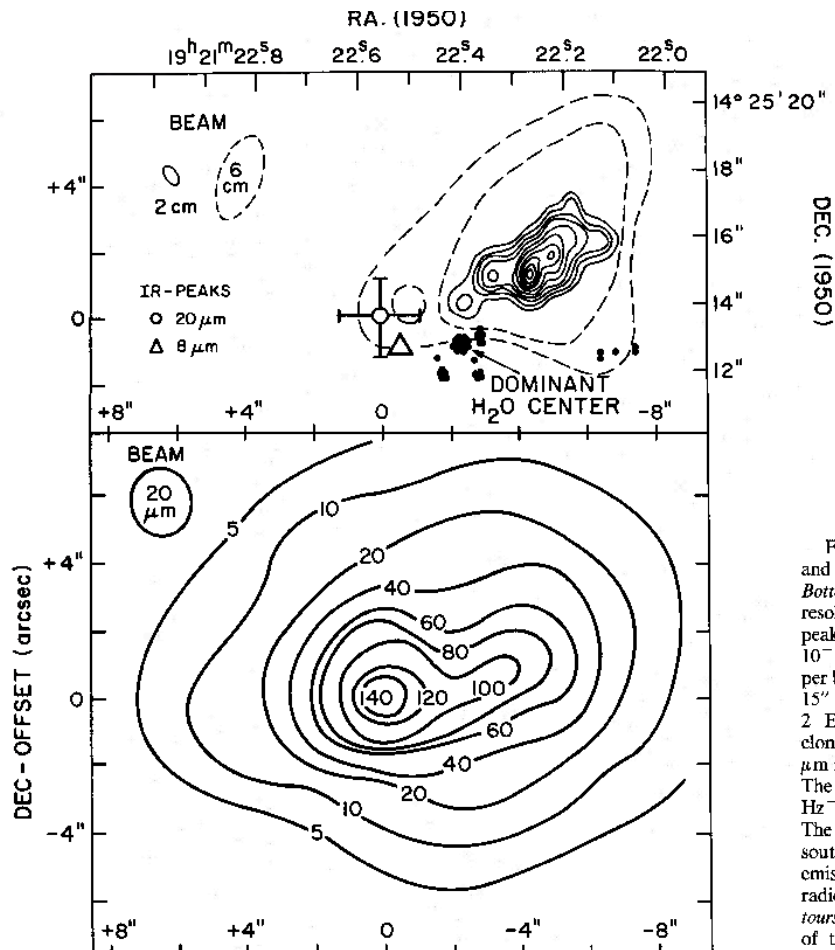
## Outline of Material

- Meeting at the IRTF in 1980
- Meeting again in ROE from 1985 to 1986
- Back in Hawaii and HH212
- Invite to Potsdam in ~1999
- The 2009 AG meeting in Potsdam and a Keck Proposal and observing
- Working together on SOFIA 2010 to 2016+

## Meeting Hans in 1980 at the IRTF on Mauna Kea

- In the Spring of 1980 I was observing at the IRTF on Mauna Kea with Gareth Wynn-Williams, Dennis Downs and Reinhard Genzel.
- We were mapping W51 at 10 and 20 micron with a single beam photometer.
- Reinhard reported there was a graduate student from Germany that wanted to come up see us observe.
- We all agreed we could not say no to such an eager student.
- The student was Hans Zinnecker.

# W51 IRS2 in radio and 20 microns Genzel et al 1982 and the IRTF on Mauna Kea



The NASA Infrared Telescope Facility on Maunakea

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## Meeting again at ROE in 1985-86

- I was invited to Royal Observatory Edinburgh for a sabbatical visit in Aug 1985 to July 1986 by Melcomb Longair
- Hans Zinnecker was also invited by Melcomb for a longer visit the overlapped with my visit.
- Ian McLean was building the first IR imager for UKIRT. IRCAM which had a 58x62 InSb detector that worked at 1 to 5 microns .
- Ian held weekly meetings to discuss future science with the new camera that both Hans and I attended. Along with graduate students Mark McCaughrean and John Rayner and many others. I remember many interesting discussions that carried over into lunch at the cafeteria. One thing that came up new for me was searching for Brown Dwarfs with the new camera.

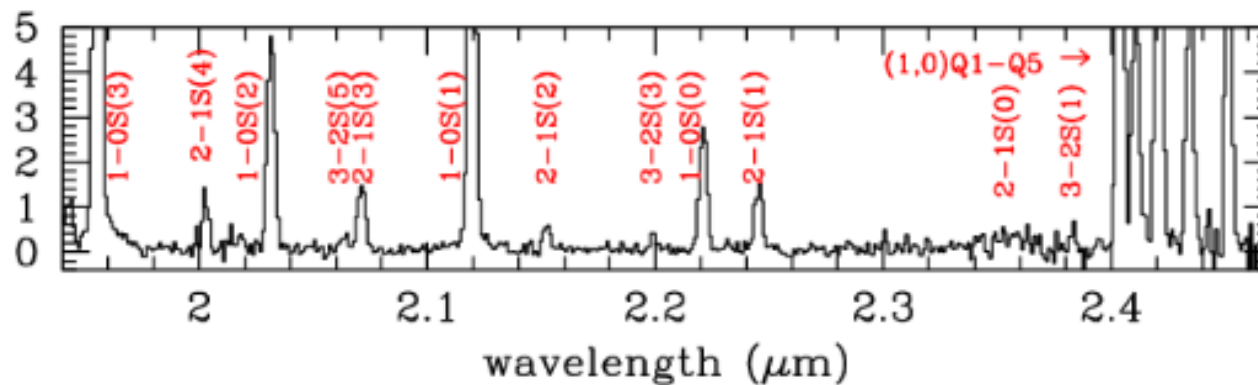
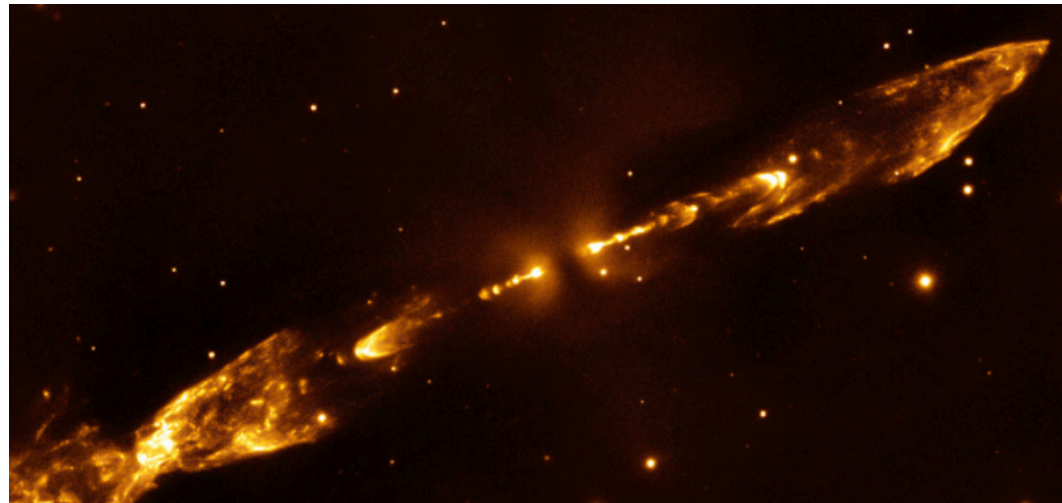
# Becklin Fest - 2005



## Meeting Hans again at meetings and in Hawaii in the 1990's and his discovery of HH212 with John Rayner and Mark McCaughrean

- In the 1990s and 2000s, I would see Hans at various meetings, especially at Brown Dwarf meetings.
- In 1993 while searching for embedded low mass stars in Orion B at the IRTF, Hans, John and Mark came across a very linear and symmetric configuration of apparent stars.
- Further study showed the objects to be emitting primarily shocked molecular hydrogen.
- In their 1998 Nature Paper they called the object HH212.
- This was one of the most spectacular discoveries I ever had seen in astronomy.

# HH212 as imaged by ESO and Shocked Molecular Hydrogen spectra (L1157 A1)





# Hans would not publish until he understood the physics of the Jets

- I remember trying to get Hans to publish this result.
- Hans said he could not publish it until he understood the physics of the jets.
- I honor Hans for sticking to his guns on wanting further understanding. However, I still think I might have been correct.

## In about 1999 Hans invited me to his new Institute in Potsdam

- I was working on SOFIA and spent quite a bit of time in Germany.
- Hans invited me to Potsdam to talk about SOFIA
- What I remembered is:
  - Seeing the “Wall”
  - The boat trip up the River and seeing where Stalin, Churchill and Truman met in summer of 1945.
  - The new astronomy building still under construction.
  - Meeting the new Institute director Gunther Hasinger.
  - Meeting Hans’ new team including Mark McCaughrean.

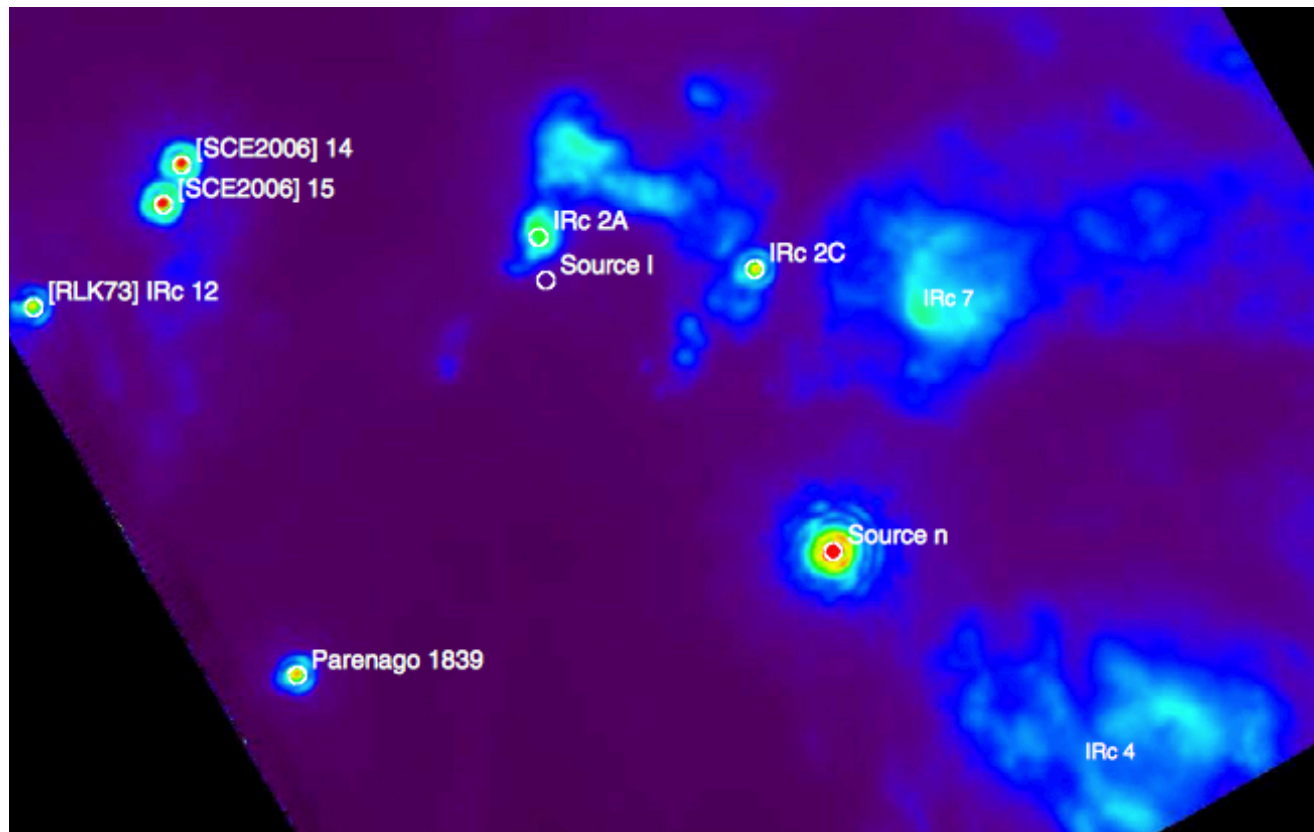
## In 2009 I returned to Potsdam for the AG meeting which Hans helped organize.

- This was a meeting I remember mostly because of long discussions with Hans on future science and the entertainment after the dinner which Hans organized.
- Hans had already decided he was coming to California to the German Deputy Director. We had many discussions about what we might do with SOFIA.
- We both felt that the best object to concentrate on was OMC1 (BNKL) in Orion and how massive stars form.
- We also decided should do some pre-observations possibly with Keck Adaptive Optics

## Putting in a Keck Proposal and Observing

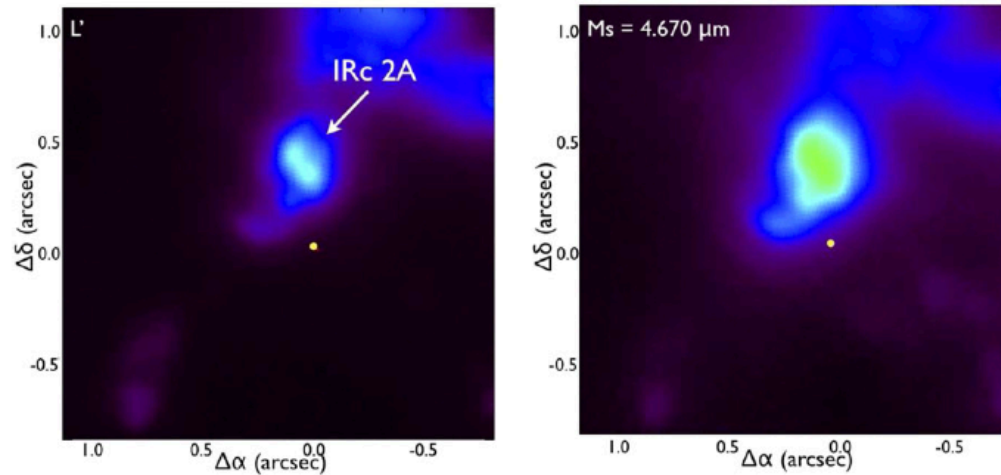
- With Keck we decided we would look at the Proper Motion of 3.8 micron stars in the OMC1 cloud to get their mass. We did this with Andrea Ghez, Mark Morris, Jessica Lu and others who agreed to work with us.
- We received the observing time and got a lot of fantastic data.
- We learned a lot about OMC1 and a 500 year old explosions and it was going to be hard to get a mass.
- A publication in 2013 (Sitarski etal ApJ) concentrated on the 3.8 and 4.7 micron morphology around IRc2A and radio source I.
- Proper Motion still needs more data.

## 3.8 Micron Keck image of central $\sim 10''$ region of OMC1 Resolution of $\sim 0.1''$ (Sitarski et al 2013 ApJ)



## The Morphology around IRc 2A and I at 3.8 microns (left) and 4,7 microns (right)

No 3.8 or 4.7 micron radiation was seen at the position of radio source I



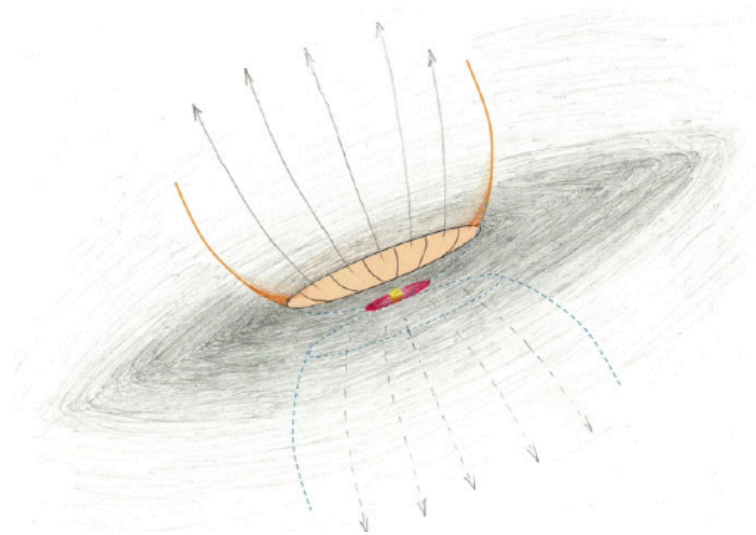
- Radio source I was believed to be a blotted massive young star associated with masers and the center of the 500 year old explosion and with a massive obscuring disk.
- The southern edge of both the 3.8 and 4.7 microns ran along the edge of the obscuring disk

# Toy model of Source I, disk. outflow cavity

## 3.8 and 4.7 micron emission

SITARSKI ET AL.

A toy model was put together by the team (mostly Mark Morris and validated by Gaspard Duchene)



- The massive disk runs perpendicular to the outflow determined by the masers.
- The clearing on the upper side allows us to see radiation on the edge of the outflow cone either scattered or thermally heated dust at 3.8 and 4.7 microns.

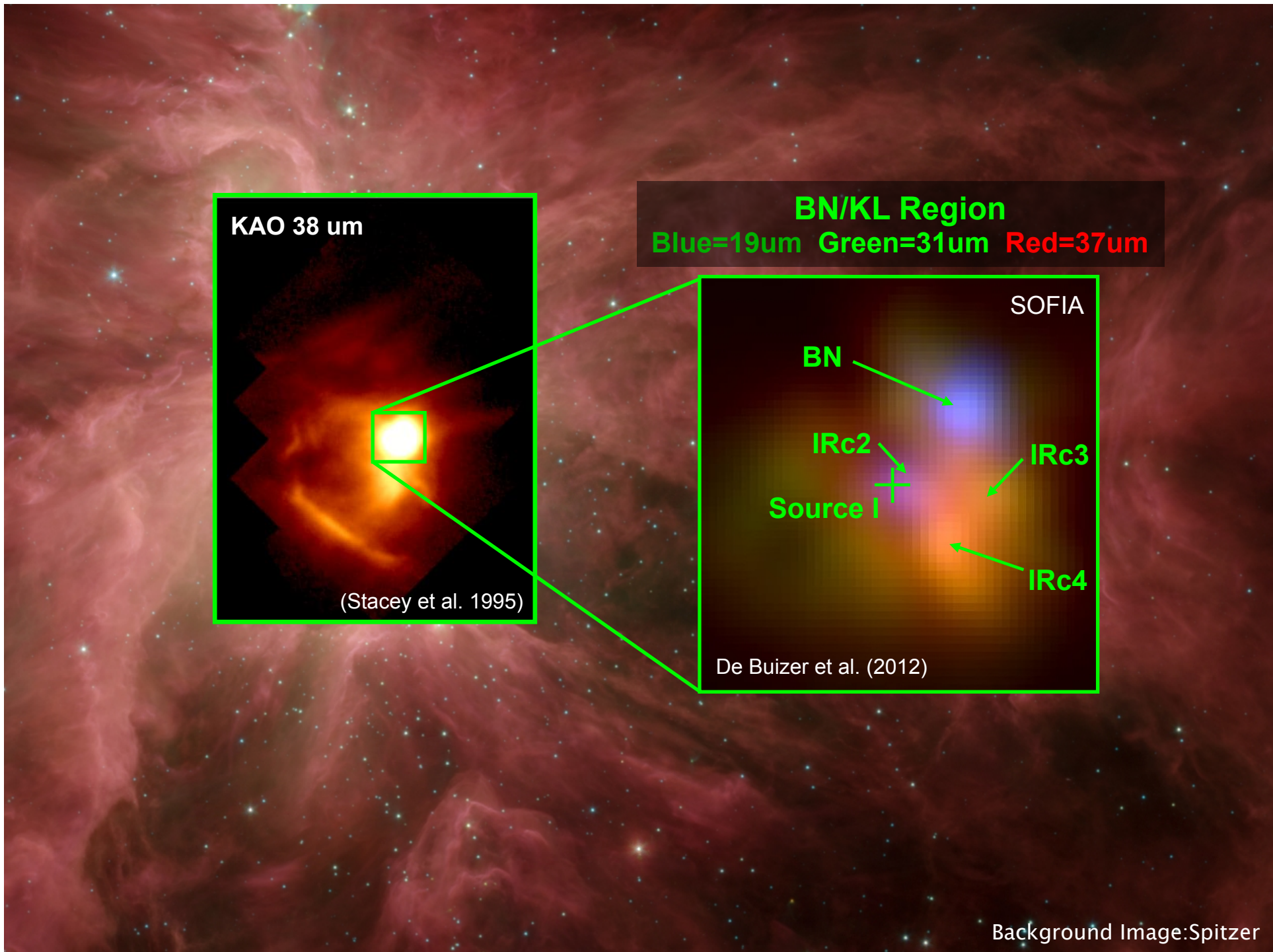
# Now on to Orion work with SOFIA: 2.5 meter telescope in the Stratosphere





# ORION NEBULA

- Orion Nebula is the closest region to the earth of Massive Star Formation
  - Distance = 415 pc
  - Both Optical stars (Trapezium) and embedded star formation (OMC 1/BNKL)
- Studied on SOFIA with FORCAST at 6 to 37 microns.
- De Buizer et al ApJ Letters 2012 Vol 749 L23



**KAO 38 um**

(Stacey et al. 1995)

**BN/KL Region**  
Blue=19um Green=31um Red=37um

SOFIA

BN

IRc2

Source I

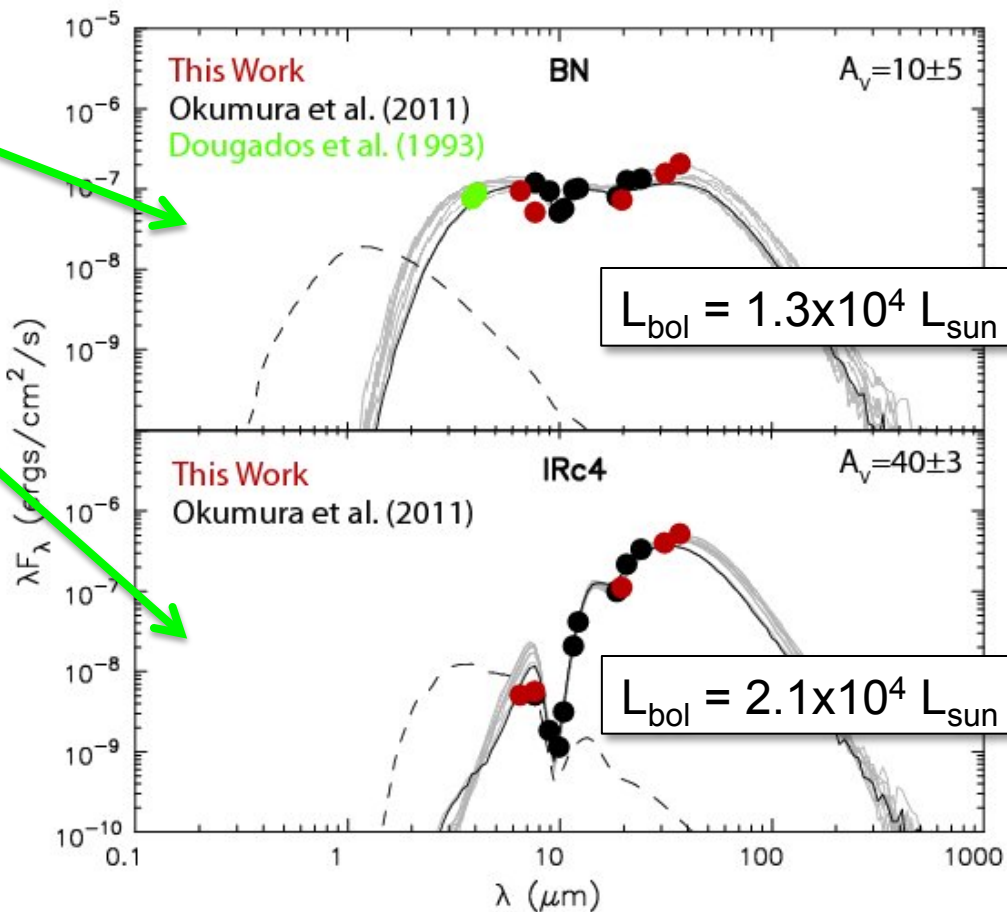
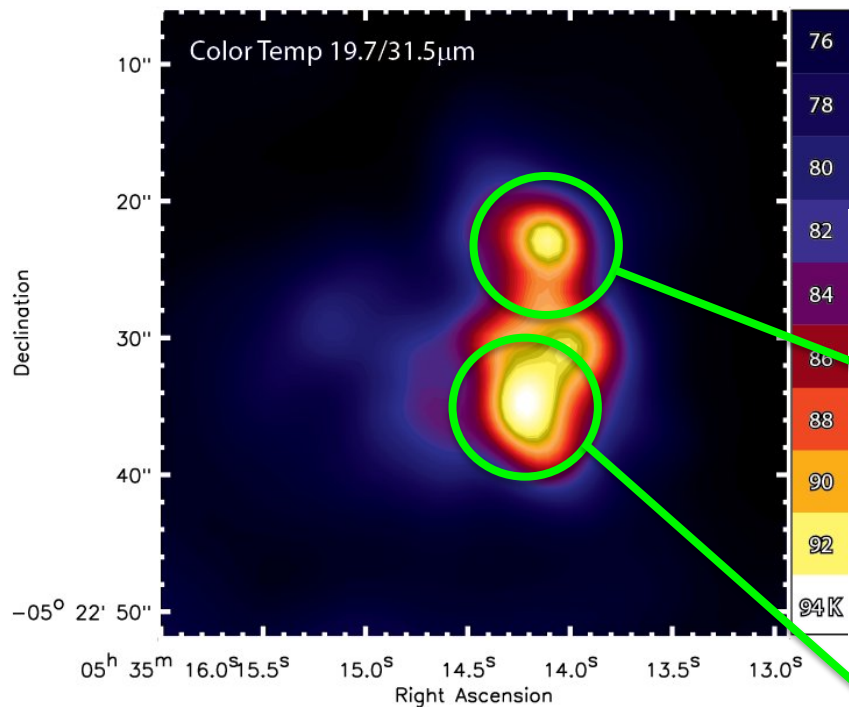
IRc3

IRc4

De Buizer et al. (2012)

Background Image:Spitzer

Like BN, IRc4 is a self-luminous source



IRc4 luminosity is too high to be caused by externally heating

BN+IRc4 account for ~50% of the  $\sim 10^5 L_{\text{sun}}$  of the BN/KL region

## Hans as Deputy Director of SOFIA 2009-2016

- Hans as the German Deputy Director made a major impact on SOFIA
- He was a world wide ambassador and promoter of SOFIA early Science. He attended most AG, AAS and IAU meetings as a representative of SOFIA. He was the prime contributor from the SMO for the SOFIA Ringberg meetings and other German workshops.
- Hans worked hard and succeeded to get the General German Science Community involved in SOFIA. Because of Hans' efforts, >50% of the German time goes to GTO time.
- He was the prime organizer of the German Telescope Allocation Committee, even to this very day!!

## Hans was always thinking about Science with SOFIA

- He was always thinking about what the observations meant.
- If possible, he would dig into the physics of what was happening. For example, he explained to me and others the lambda doubling of SH SOFIA detected lines and how OI and CII work from the physics and astrophysics side.
- Hans also got me involved in interesting meetings. I.e Richard Larson conference Frontiers of Star Formation in 2012 at Yale and reconnection with Guito Munch.
- Last Sept. (2017) on a visit to UCLA to discuss Magnetic Fields and Star Formation in the Galactic Center with Mark Morris, Hans took time to work with me on an outline of my Russell Prize lecture.
- Hans wants you to know that the next SOFIA Ringberg meeting is 20-23 Jan 2019:

<https://events.mpifr-bonn.mpg.de/indico/event/87/>

# Dirk, Eric and Hans at the 2018 AAS Washington DC

## Thank You Hans!!

