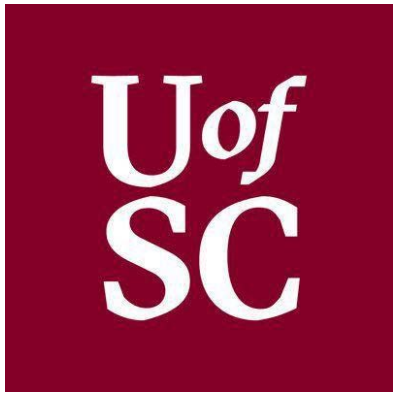
A STUDY OF FAR INFRARED LOOP AT -61° LATITUDE

University of South Carolina

Columbia



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BACKGROUND

1. Interstellar Medium

- Matter and radiation exit in the space between stars.

  - Gases (H_2 & He)
  - Dusts (Silicate, Graphite, ice, carbon compound)
  - Cosmic rays
  - Magnetic field

2. Infrared Astronomy

- Electromagnetic Radiation (gamma rays, X-rays, ultraviolet, visible, infrared, microwave and radio wave)
- Detection and Study of Infrared radiation.
- Every object that has temperature radiates in infrared.

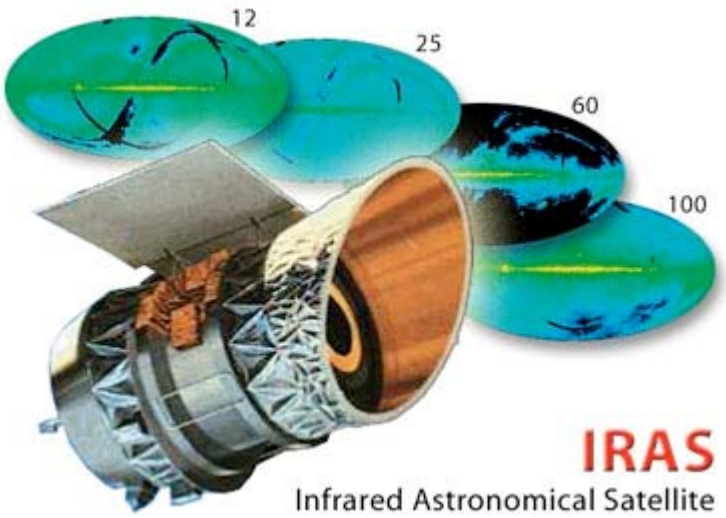
Spectral Region	Wavelength Range (microns)	Temperature Range (Kelvin)	What We See
Near- Infrared	(0.7-1) to 5	740 to (3000-5200)	Color red star, Red Giants Dust is transparent
Mid- Infrared	5 to (25-40)	(92.5-140) to740	Planets, comets and asteroid Dust warmed by starlight
Far- Infrared	(25-40) to(200-350)	(10.6-18.5) to (92.5-140)	Emission from cold dust Central region of galaxies Very cold molecular clouds

Source: NASA IPAC “cool cosmos” site

BACKGROUND

3. IRAS Survey

- The first ever telescope to perform a survey of entire night sky at infrared wavelength.
- A joint project of the United States (NASA), the Netherlands (NIVR) and United Kingdom (SERC)
- 12, 25, 60, 100 µm (350,00 sources discovered)



fig; Artist's Depiction of IRAS (Wikipedia)

RA2 mapped 96% of sky four times at 12, 25,60, 100 micfron

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OBJECTIVES

- **To find an isolated cavity and its possible association using IRAS surveys**
- **To study the physical properties (dust mass, dust temperature and Planck's function etc.) of cavity**
- **The stability and the evolution of the cavity will be discussed using published literatures.**

THEORY

1. Far Infrared-loop

- Cosmic bubble bath (arc, loops, filament, cavity, shells)
- Supernova Explosion & Stellar winds of associations
- Supersonic Turbulence may play important role in ruling of structure of ISM, creating clouds and cavities.
- Kiss et al. (2004) catalogued 145 loops in 2^{nd} galactic Quadrant.
- Koenyves et al. (2007) extended the search in 1^{st} ,3^{rd} and 4^{th} Quadrant, found 317 loops.
- These two works provide the catalogued of Far-Infrared loops in the Galaxy.
- Also known as KK loops.

THEORY

4. Dust Color Temperature

- It is generally equivalent temperature of dust due to its color
- According to Schnee et al. (2005), the flux density at λi is given by

$$F_i = \left[\frac{2hc}{\lambda_i^3(e^{\frac{hc}{\lambda_i K T_d}} - 1)}\right] N_d \alpha \lambda_i^{-\beta} \Omega_i$$

where α is a constant that relates the flux to optical depth of the dust, Ωi is the solid angle subtended by the detector

- According to Wood et al. (2005), Ω(60)=Ω(100) and dusts are in thermal equilibrium, we have the formulas for $\boldsymbol{T_d}$ as

$$\boldsymbol{T_d = -\frac{96}{ln\{R \times 0.6^{(3+\beta)}\}}}$$

Where, $\mathbf{R = \frac{F(60\mu m)}{F(100\mu m)}}$

Here β is the emissivity spectral index depends on dust, grain properties.

THEORY

5. Dust Mass

- The flux density from a cloud at distance D containing N spherical dust grain of size a, cross section σ and emissivity Q(ϑ) is given as

$$F(v) = N\left[\frac{\sigma}{D^2}\right] Q(v) B(v,T)$$

Suppose v be the volume of each dust grain, then total volume of the cloud is V=Nv , where $v = \frac{4}{3}\pi a^3$, and $\sigma = \pi a^2$.

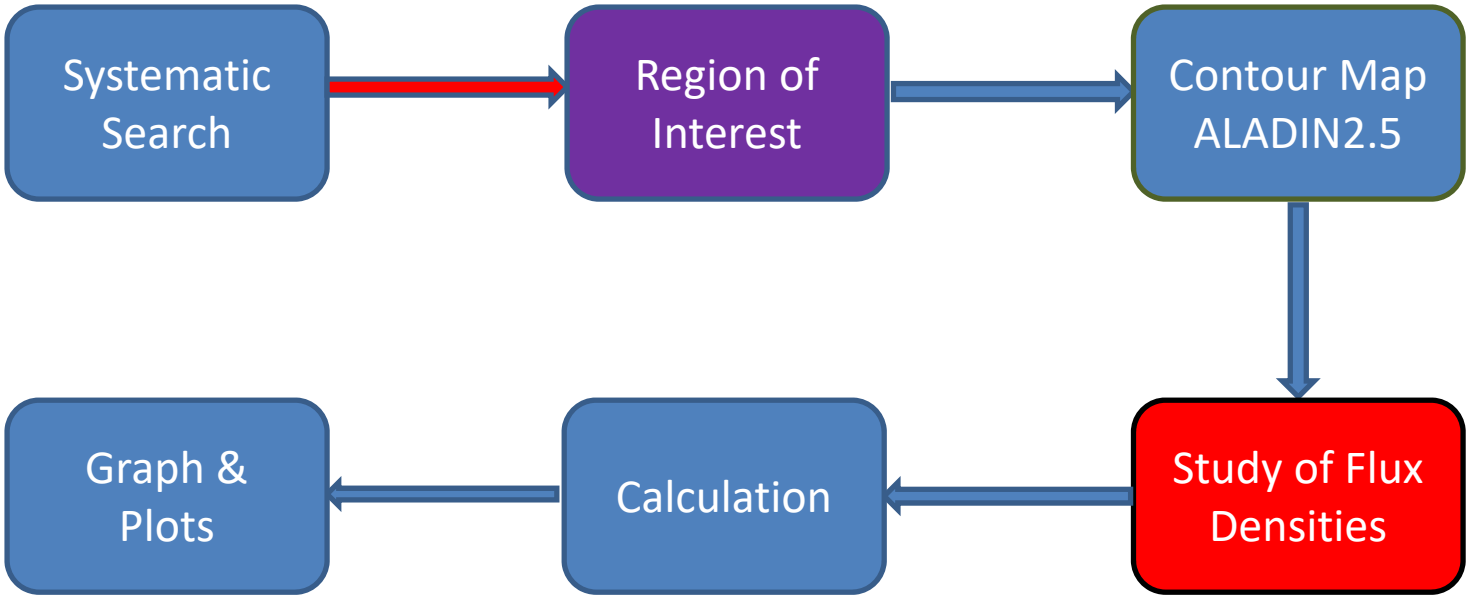
- The dust mass is given by

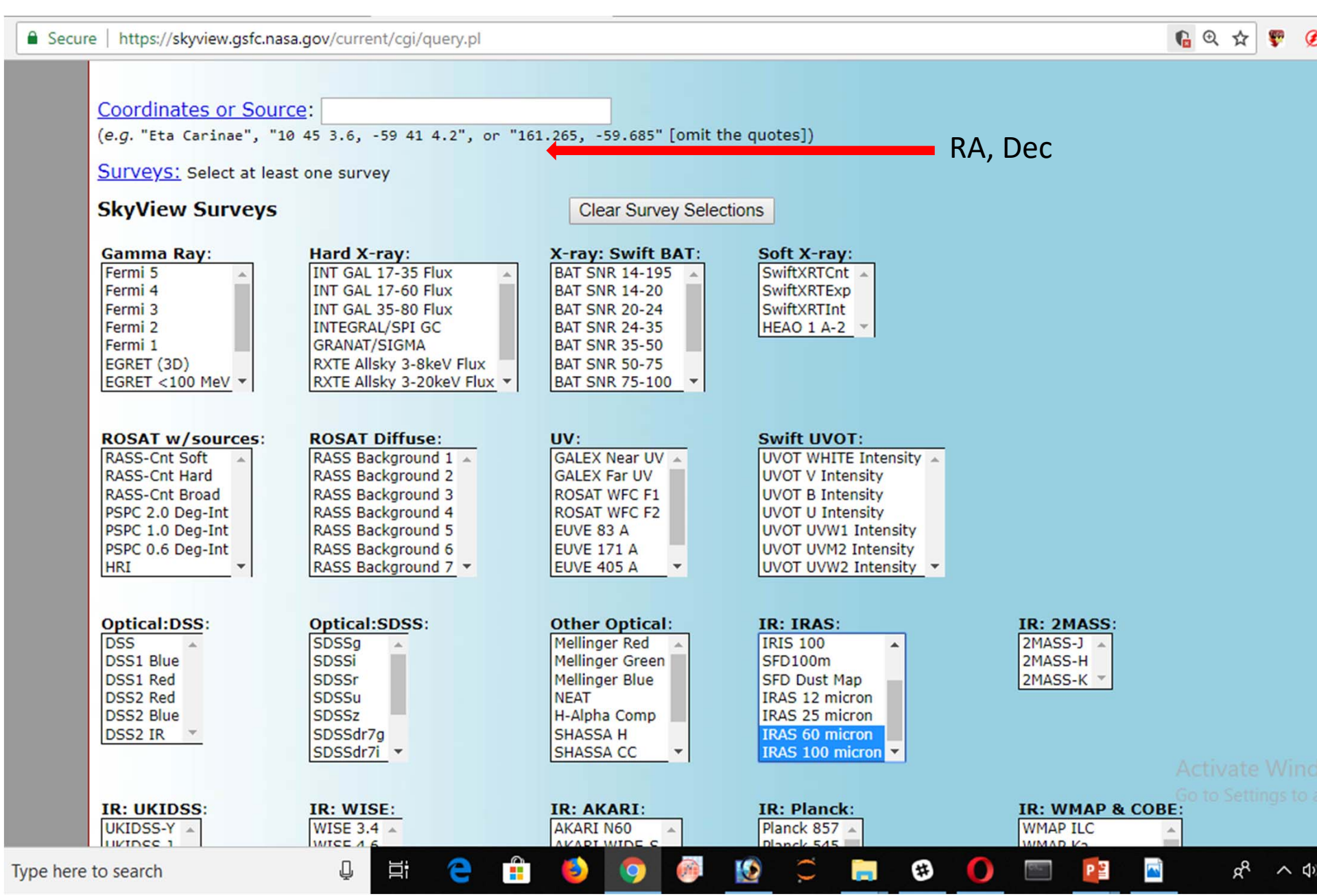
$$M = V\rho = \left[\frac{F(v)D^2}{B(v,T)}\right]\left[\frac{4a}{3Q(v)}\right]\rho$$

- Young et al. (1993) suggested that a= 0.1 μm, ρ=3000kgm^{-3} and Q(v)=0.001 and 0.0046 for 100 μm and 60 μm , then

$$\boldsymbol{M_{dust} = 0.4\left[\frac{F_v D^2}{B(v,T)}\right]} \qquad \text{where} \qquad \boldsymbol{B(v,T) = \frac{2hv^3}{c^2}\left[\frac{1}{e^{\frac{hv}{kT}} - 1}\right]}$$

METHODOLOGY

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Coordinates or Source:
(e.g. "Eta Carinae", "10 45 3.6, -59 41 4.2", or "161.265, -59.685" [omit the quotes])
RA, Dec
Surveys: Select at least one survey
SkyView Surveys
Clear Survey Selections
Gamma Ray:
Fermi 5
Fermi 4
Fermi 3
Fermi 2
Fermi 1
EGRET (3D)
EGRET <100 MeV
Hard X-ray:
INT GAL 17-35 Flux
INT GAL 17-60 Flux
INT GAL 35-80 Flux
INTEGRAL/SPI GC
GRANAT/SIGMA
RXTE Allsky 3-8keV Flux
RXTE Allsky 3-20keV Flux
X-ray: Swift BAT:
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BAT SNR 20-24
BAT SNR 24-35
BAT SNR 35-50
BAT SNR 50-75
BAT SNR 75-100
Soft X-ray:
SwiftXRTCnt
SwiftXRTExp
SwiftXRTInt
HEAO 1 A-2
ROSAT w/sources:
RASS-Cnt Soft
RASS-Cnt Hard
RASS-Cnt Broad
PSPC 2.0 Deg-Int
PSPC 1.0 Deg-Int
PSPC 0.6 Deg-Int
HRI
ROSAT Diffuse:
RASS Background 1
RASS Background 2
RASS Background 3
RASS Background 4
RASS Background 5
RASS Background 6
RASS Background 7
UV:
GALEX Near UV
GALEX Far UV
ROSAT WFC F1
ROSAT WFC F2
EUVE 83 A
EUVE 171 A
EUVE 405 A
Swift UVOT:
UVOT WHITE Intensity
UVOT V Intensity
UVOT B Intensity
UVOT U Intensity
UVOT UVW1 Intensity
UVOT UVM2 Intensity
UVOT UVW2 Intensity
Optical:DSS:
DSS
DSS1 Blue
DSS1 Red
DSS2 Red
DSS2 Blue
DSS2 IR
Optical:SDSS:
SDSSg
SDSSi
SDSSr
SDSSu
SDSSz
SDSSdr7g
SDSSdr7i
Other Optical:
Mellinger Red
Mellinger Green
Mellinger Blue
NEAT
H-Alpha Comp
SHASSA H
SHASSA CC
IR: IRAS:
IRIS 100
SFD100m
SFD Dust Map
IRAS 12 micron
IRAS 25 micron
IRAS 60 micron
IRAS 100 micron
IR: 2MASS:
2MASS-J
2MASS-H
2MASS-K
IR: UKIDSS:
UKIDSS-Y
IR: WISE:
WISE 3.4
IR: AKARI:
AKARI N60
IR: Planck:
Planck 857
IR: WMAP & COBE:
WMAP ILC
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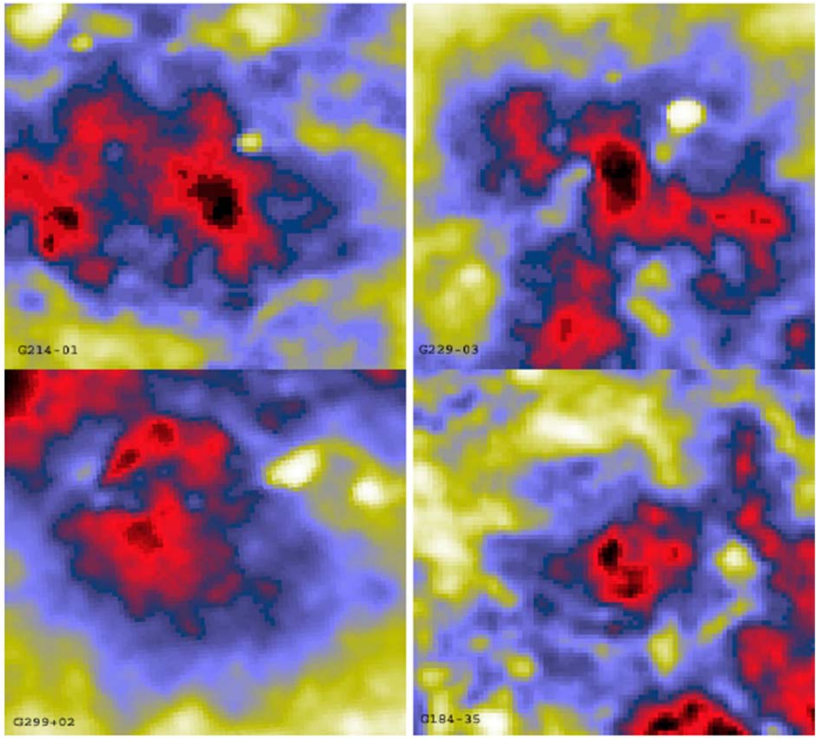
METHODOLOGY

2. Region of Interest

- Out of 50 IR loops, 4 IR loops are considered for further study (depending upon symmetric and isolated cavity)



METHODOLOGY

- From these 4 IR loops, we have selected the loop G299+02 as region of interest based on following reasons:
  - Distance
  - Not vigorously studied (known from SIMBAD)
  - Appear to be symmetric and isolated

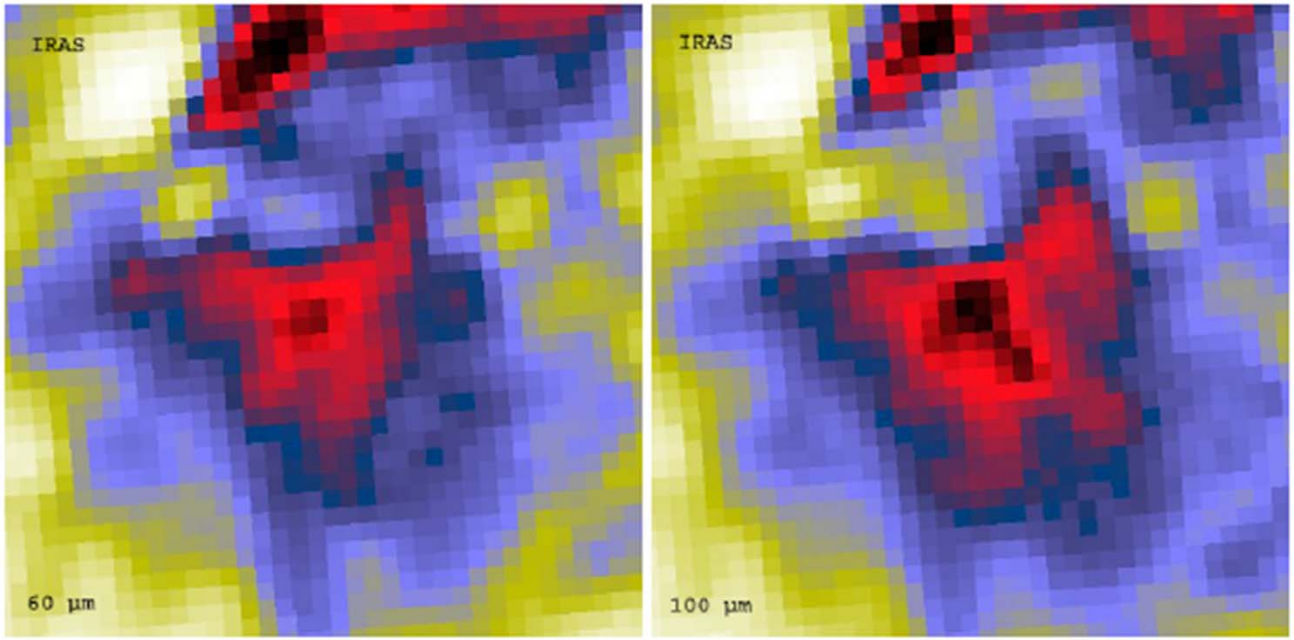
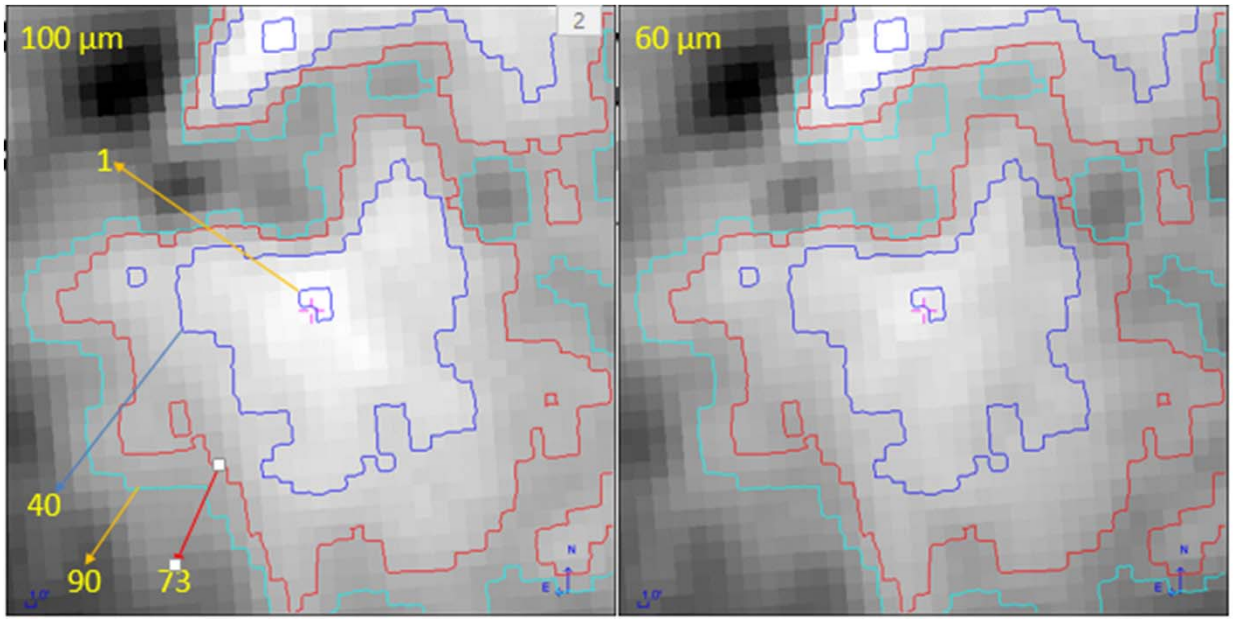


Fig.: IRAS images of the region of interest at 60 and 100 µm band, where we can see the cavities clearly. The dark region represents the low flux density region.

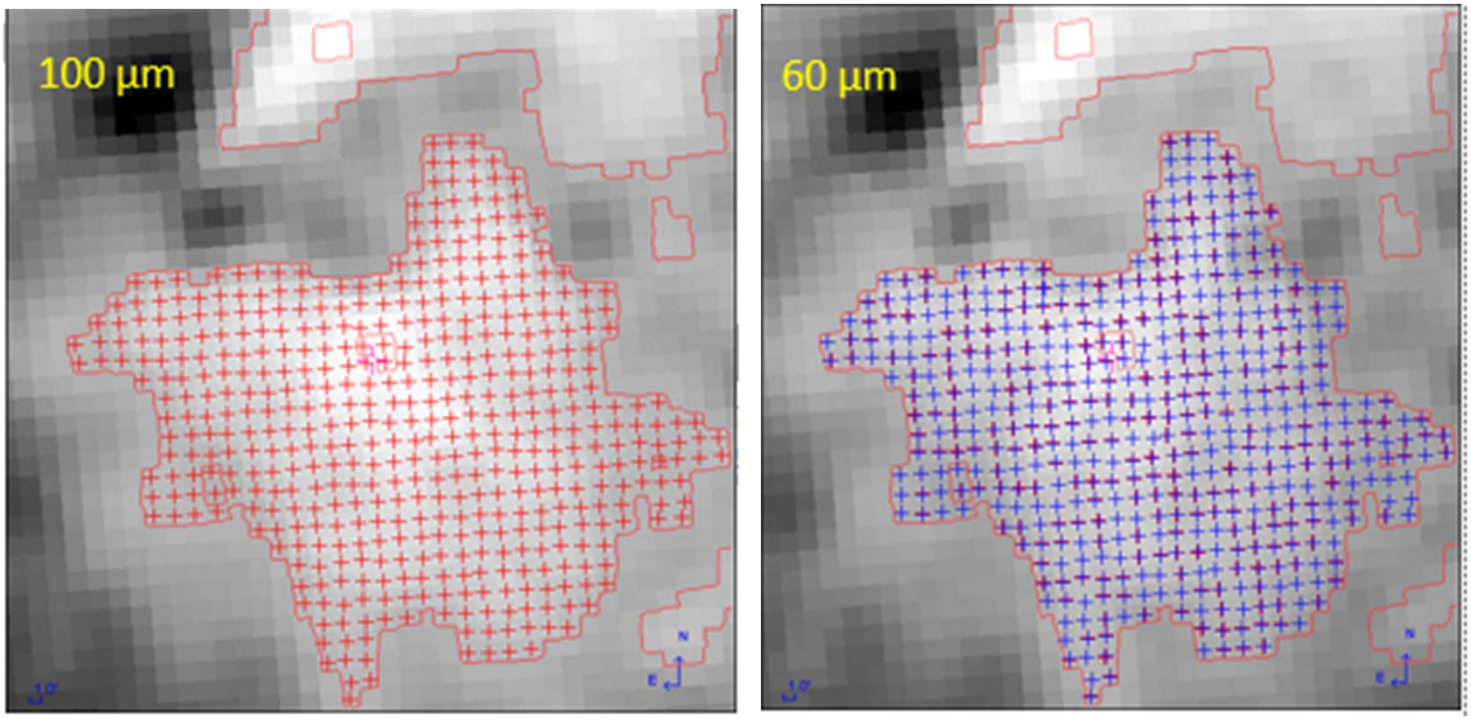
3. Contour Map

- Drawn isocontour at different levels so that we can separate regions of maximum and minimum flux density.
- Contours are drawn as to include maximum features of the region with the help of ALADIN2.5.



4. Study of Flux Density

- Each pixels of the cavity at 60 and 100 µm are tagged and corresponding flux densities are noted.



5. Calculation

- Dust Color Temperature

$$T_d = -\frac{96}{ln\{R \times 0.6^{(3+\beta)}\}}$$

- Dust Mass

$$M_{dust} = 0.4\left[\frac{F_\nu D^2}{B(\nu,T)}\right]$$

- Planck's Function

$$B(\nu,T) = \frac{2h\nu^3}{c^2}\left[\frac{1}{e^{\frac{h\nu}{kT}}-1}\right]$$

- Major and Minor diameter

6. Graph & Plots

- F(60) VS F(100) plot
- Contour Maps of Dust Color Temperature & Dust Mass
- Gaussian Plots of Dust Color Temperature & Dust Mass
- Distribution of Planck's Function along Major & Minor diameter

RESULT & DISCUSS

1. F(60) VS F(100) Plot

- Positive correlation can be seen.
- Lower values of flux density are found in limited region, whereas data are populated in higher values of flux density.
- More scatter from fitted line and more data's seen in mid values of flux density.
- Temperature found to be 23.48 K

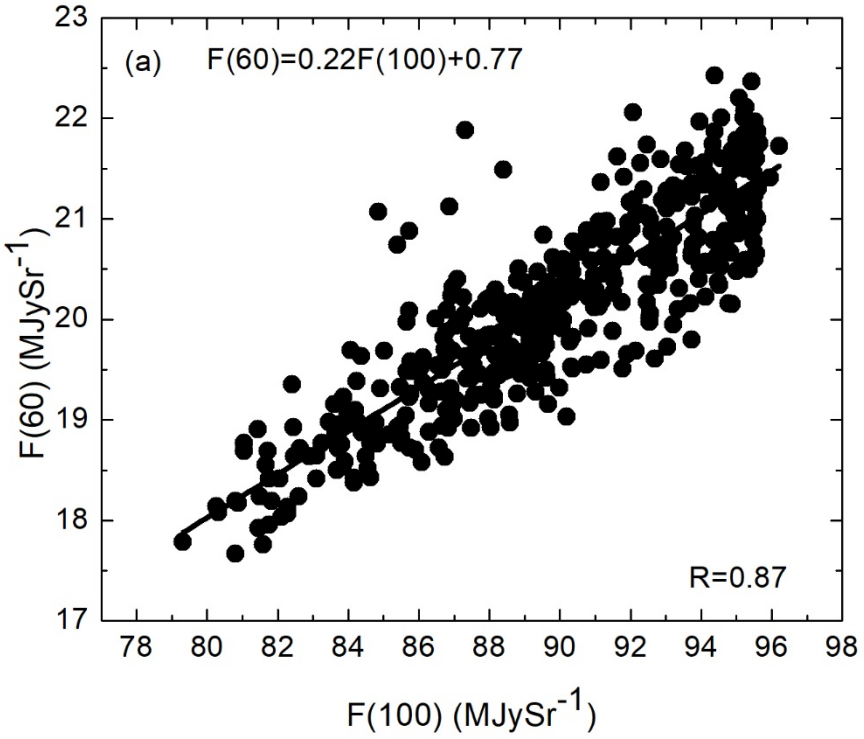
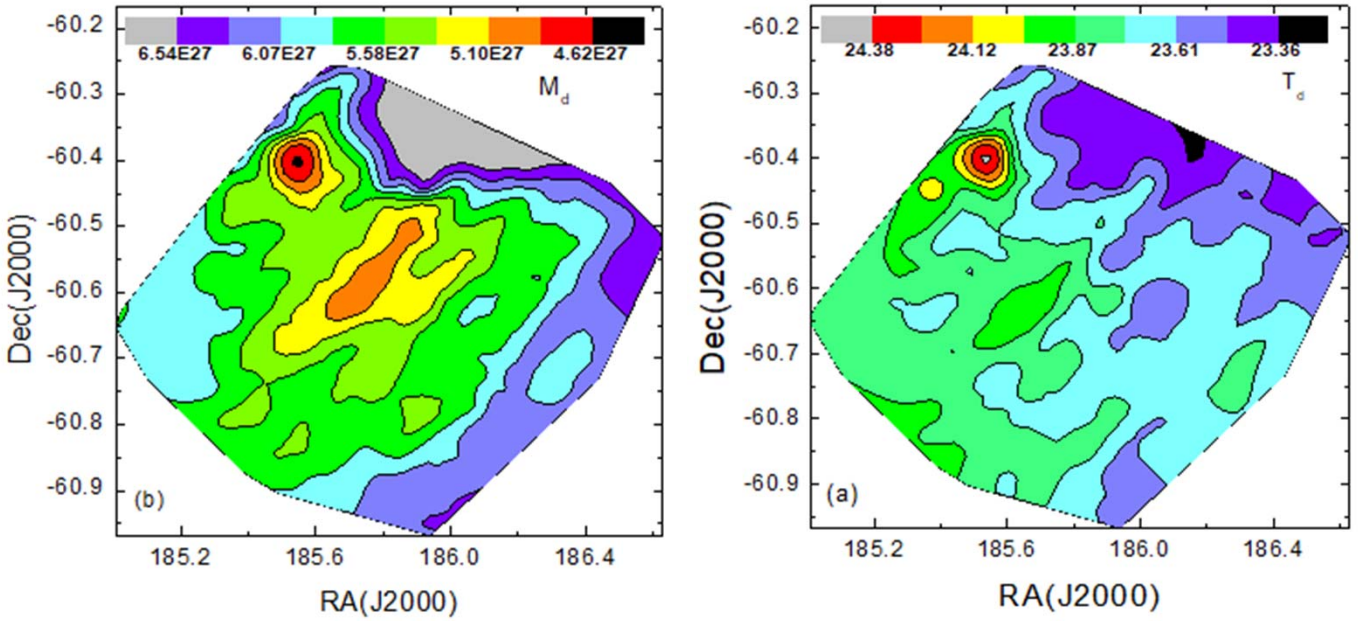


Fig.: F(60) vs F(100) plot

RESULT & DISCUSS

3.Contour Maps of Dust Color Temperature & Dust Mass



- Following the trend that higher the dust mass, lower is the dust temperature.

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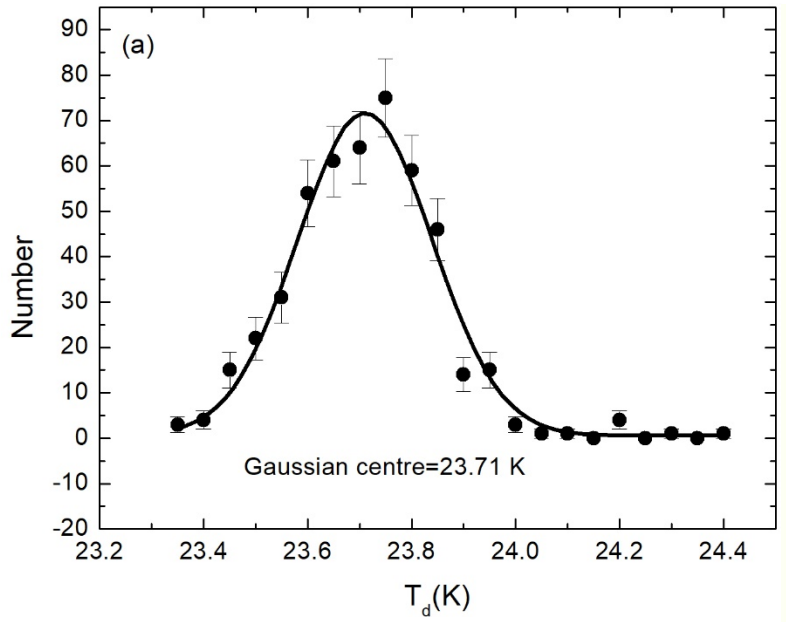
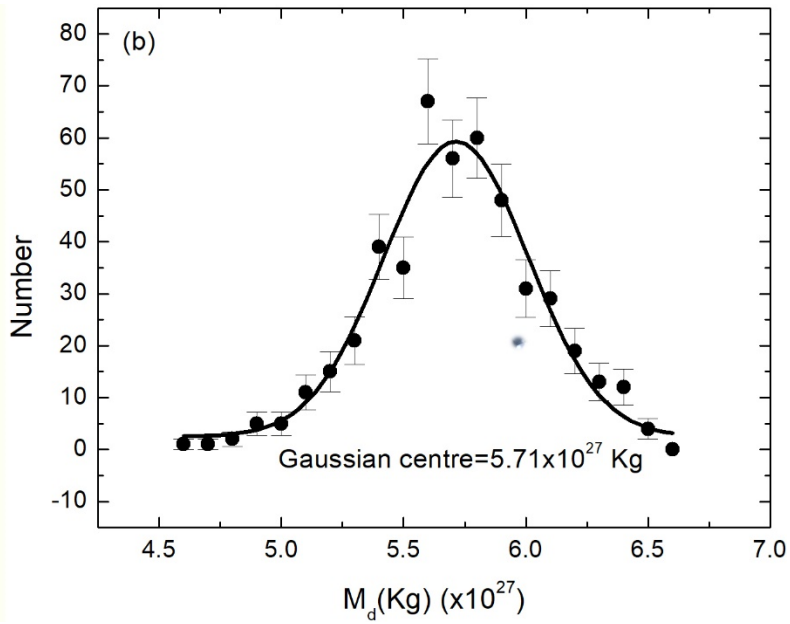
RESULT & DISCUSS

4. Gaussian Plot of Dust Color Temperature & Dust Mass

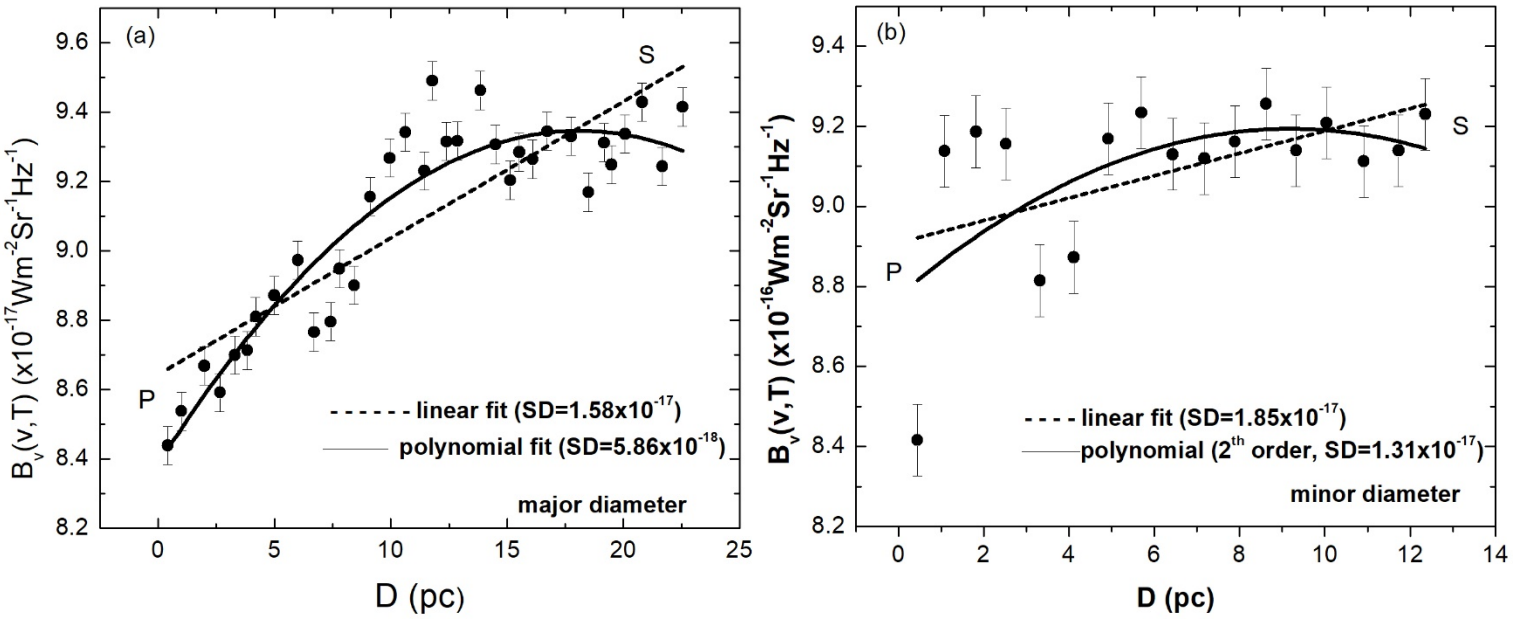




- The distribution of dust mass and dust temperature show a deviation from the normal gaussian distribution.

RESULT & DISCUSS

5. Distribution of Planck's Function along Extension & Compression



- The value of Planck's function is dependent on the distance along major and minor diameter of the cavity.

CONCLUSION

- The dust color temperature is found to be in the range 23.34 ± 0.07 to 24.38 ± 0.45 K. An offset of less than 5 K suggests that the cavity is relatively stable.
- The distribution of dust color and dust mass showed a deviation from Gaussian distribution, suggesting the effect of external cause, possibly wind blower (e.g., AGB wind, stellar supersonic wind, supernova explosion etc.)
- The dust color temperature and dust mass show an expected trend: lower the temperature, higher the density (or mass). This suggests homogeneous distribution of matter satisfying cosmological principle.
- The distribution of Planck's function along the extension and compression of the cavity is found to be non uniform, suggesting that the dust and grains are not in LTE with the radiation field.

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Thank you