Dust for Dummies

Maud Galametz
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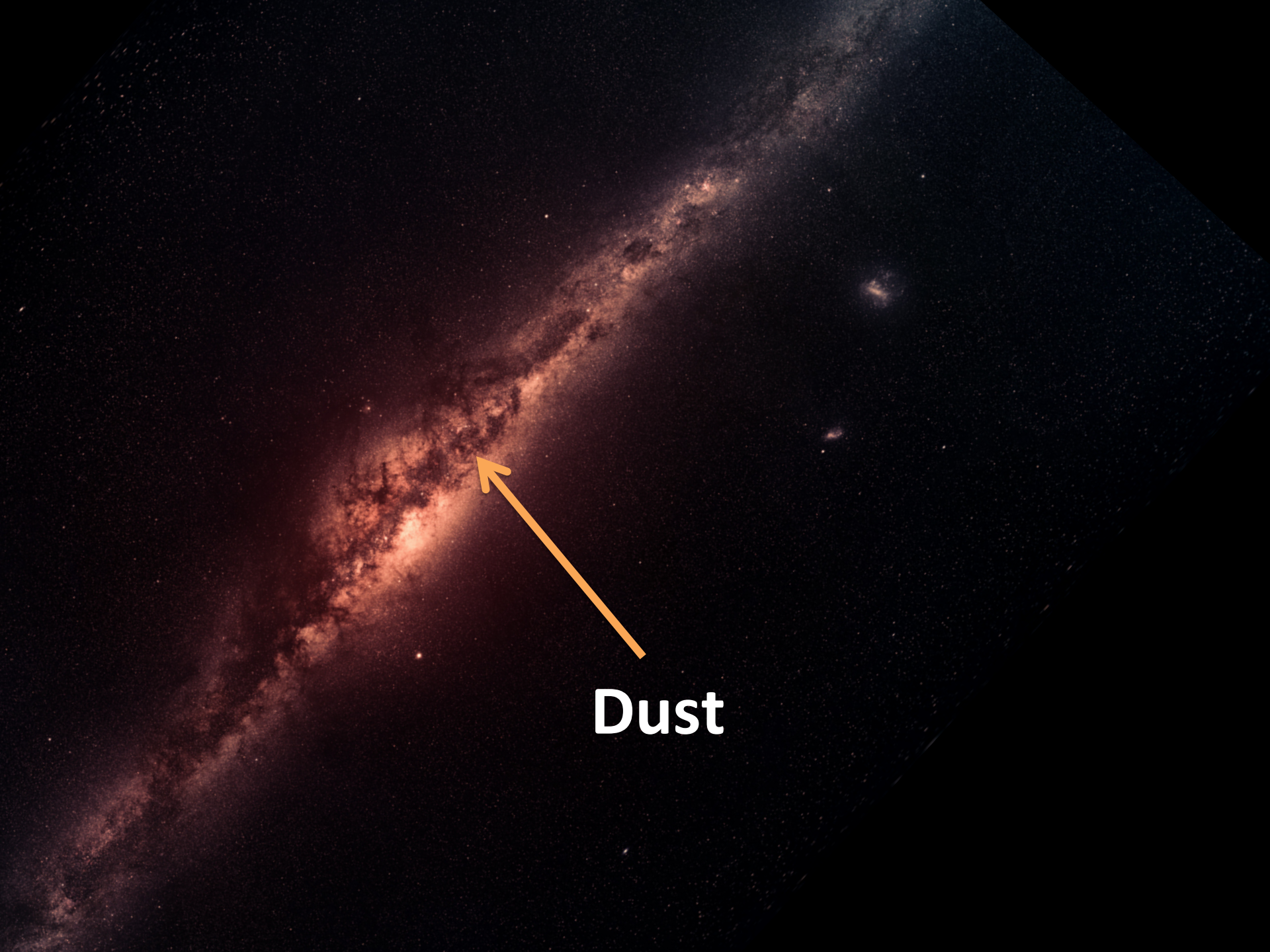
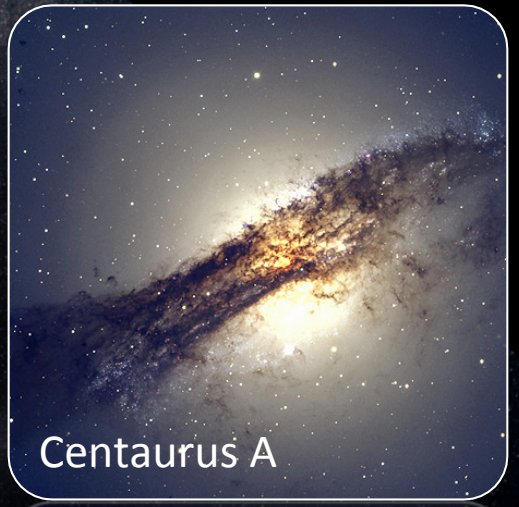
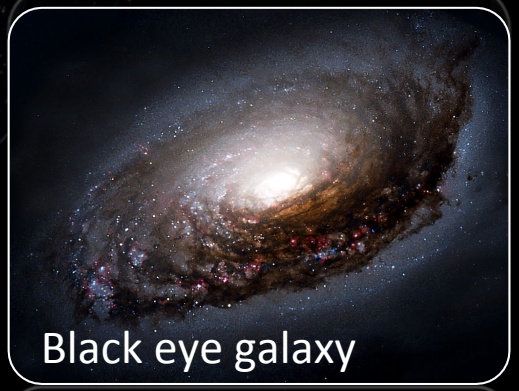
(Room 5.1.5)


Dust

Dust


Centaurus A

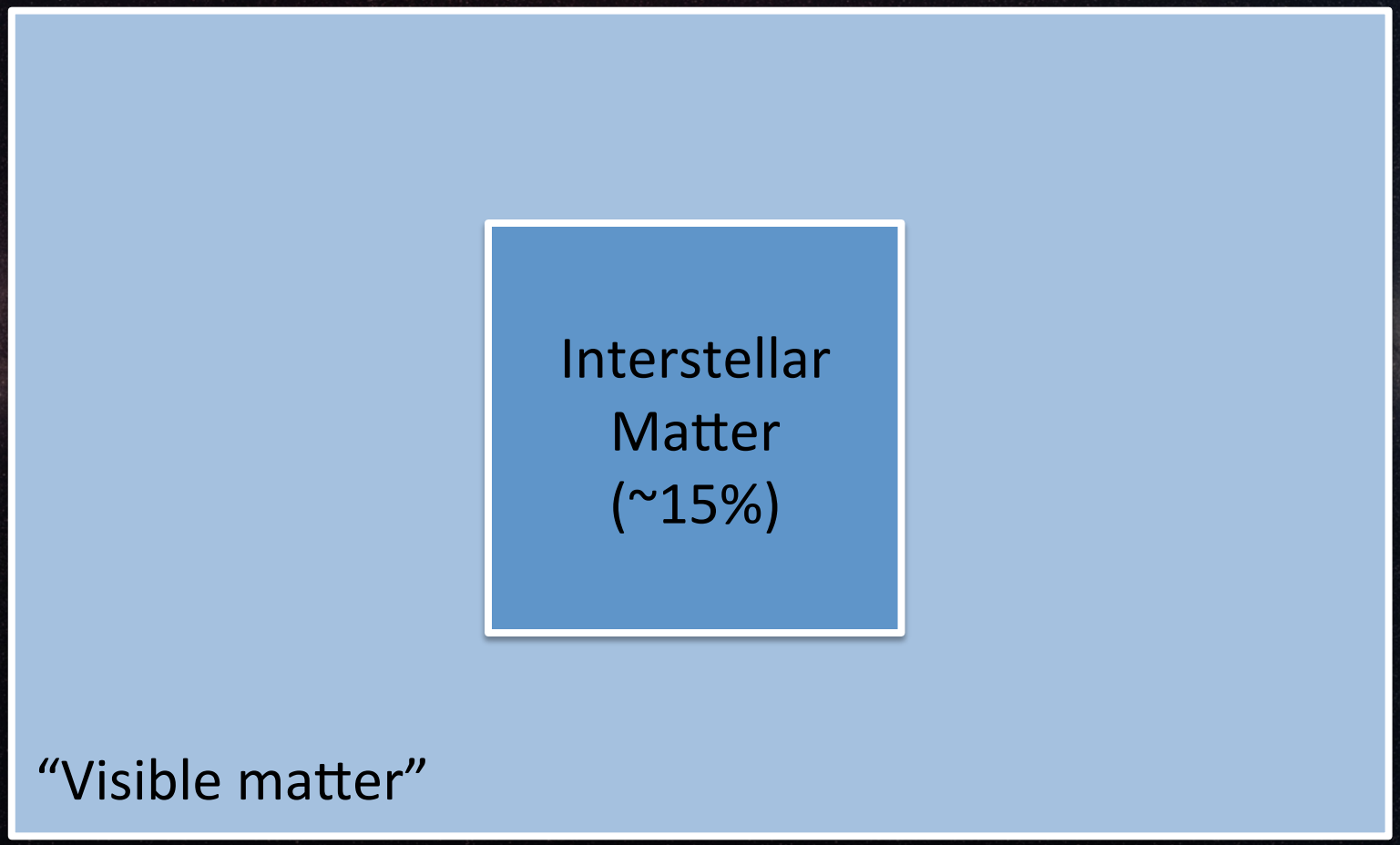

Sombrero galaxy


Black eye galaxy

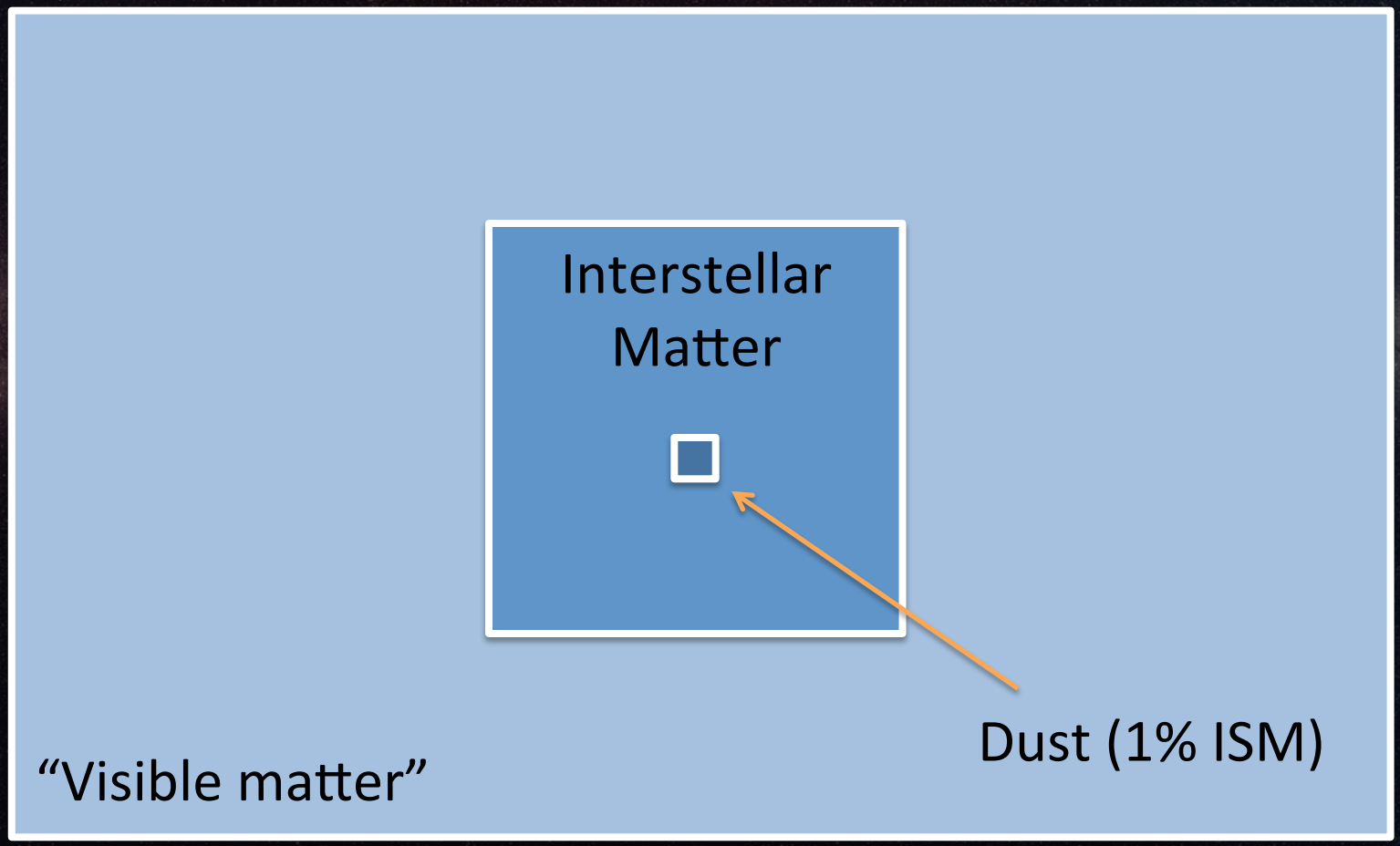
Dust fraction in a galaxy

Dust fraction in a galaxy

Dust fraction in a galaxy



Dust fraction in a galaxy



Why do we care about dust?

Why do we care about dust?

We want to know how stars are born

Visible light

Very difficult to see through the dust!

Visible matter

Why do we care about dust?

The magic of Infrared light

Visible light

Infrared light

Why do we care about dust?

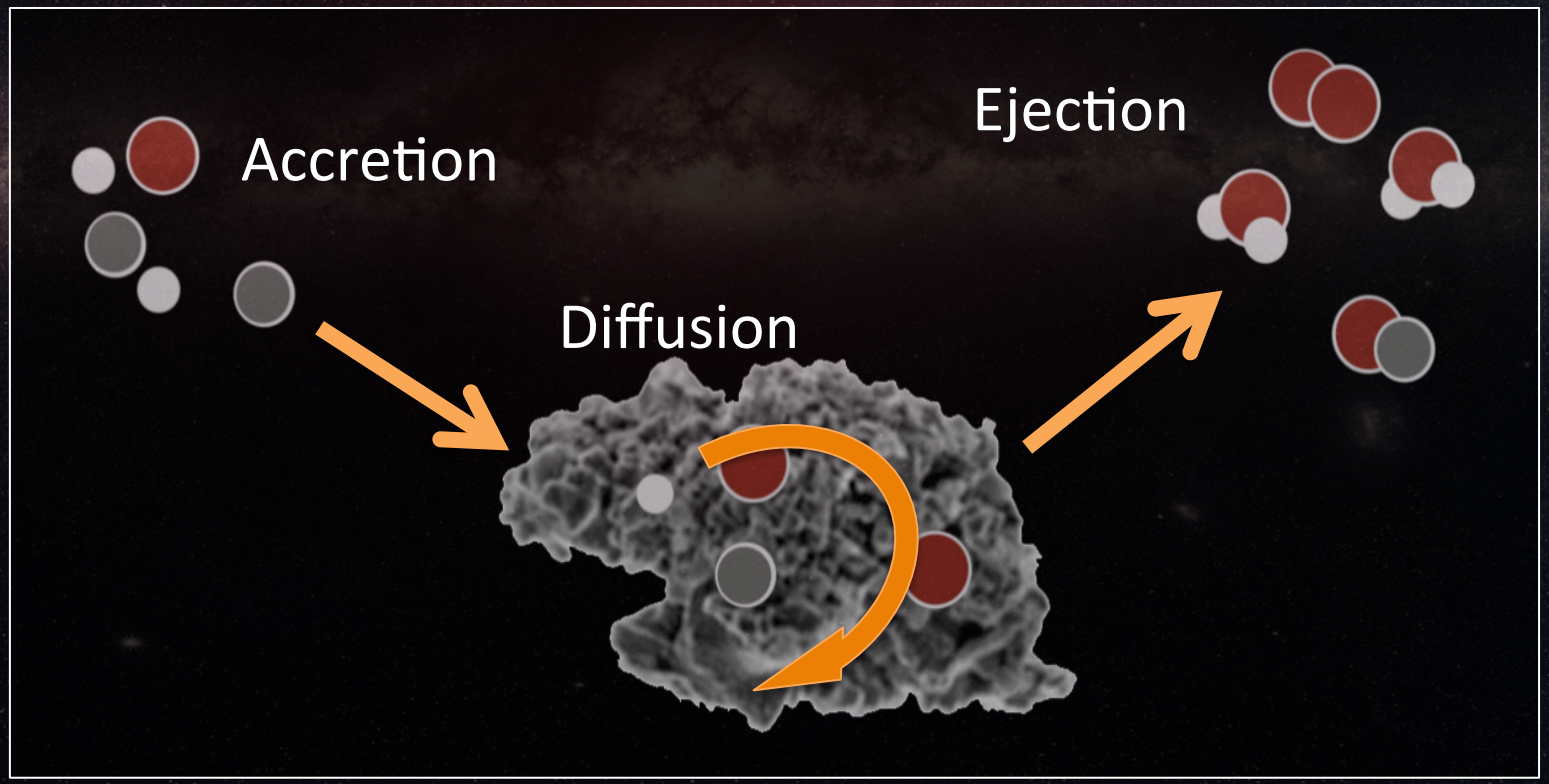
→ Dust reveals the birth place of stars

Visible light

Infrared light

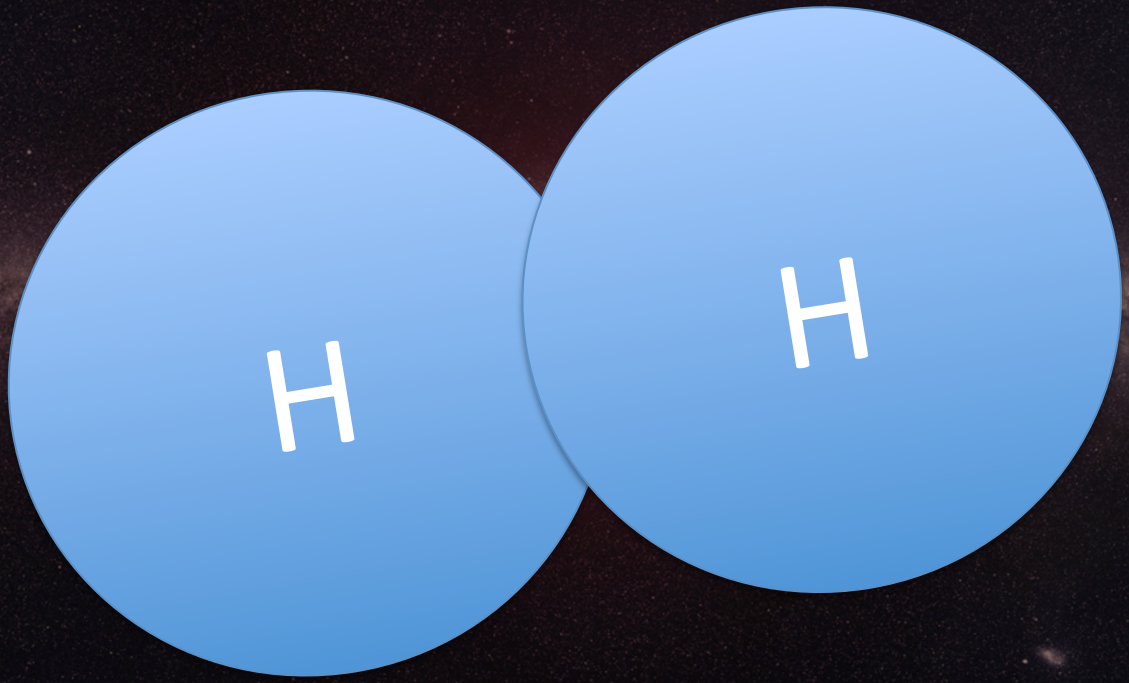
Why do we care about dust?

→ Dust is a very efficient matchmaker



Why do we care about dust?

Especially the molecular hydrogen



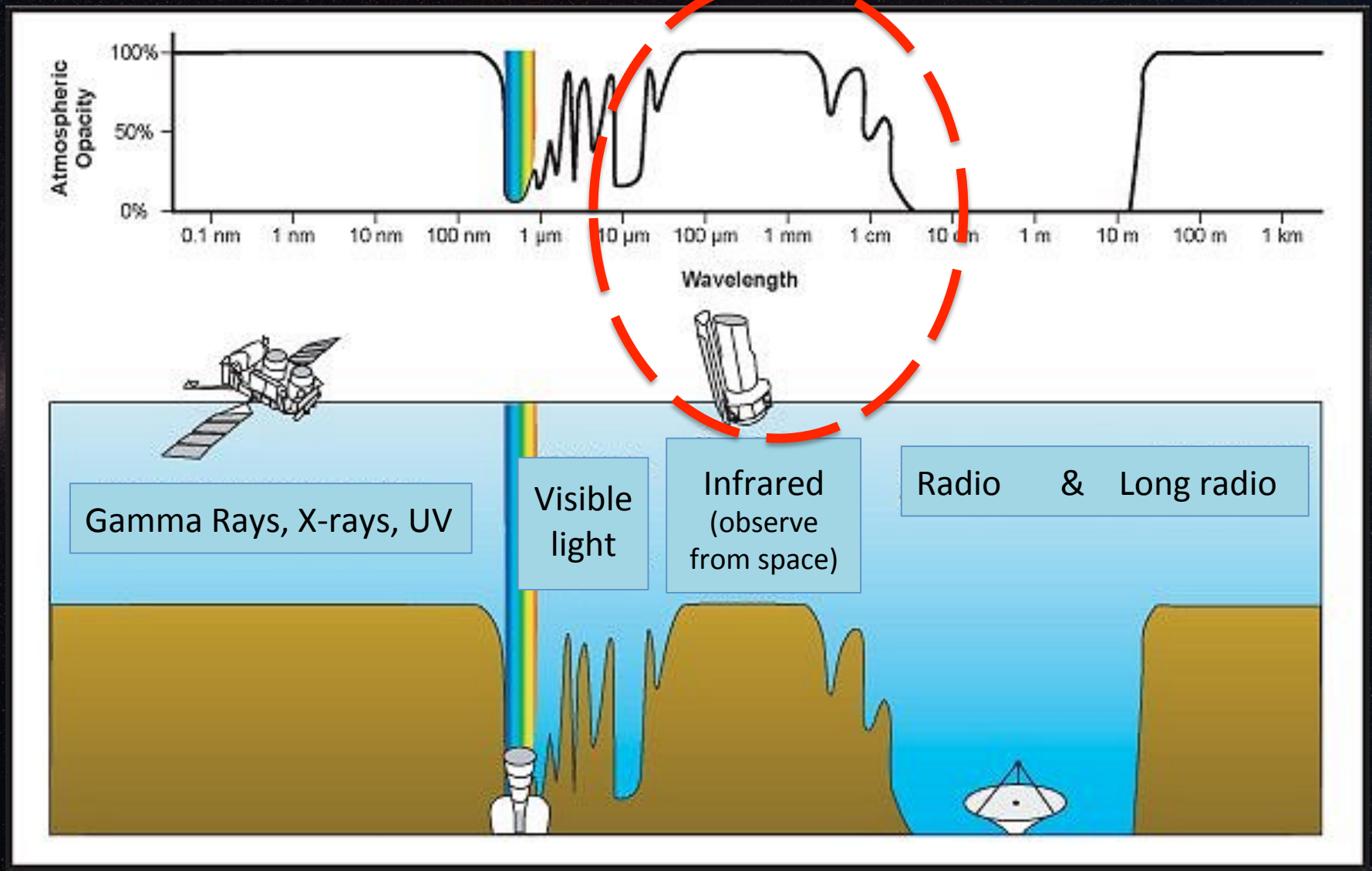
Role of the dust:
- Formation
- Survival

We are made of stardust

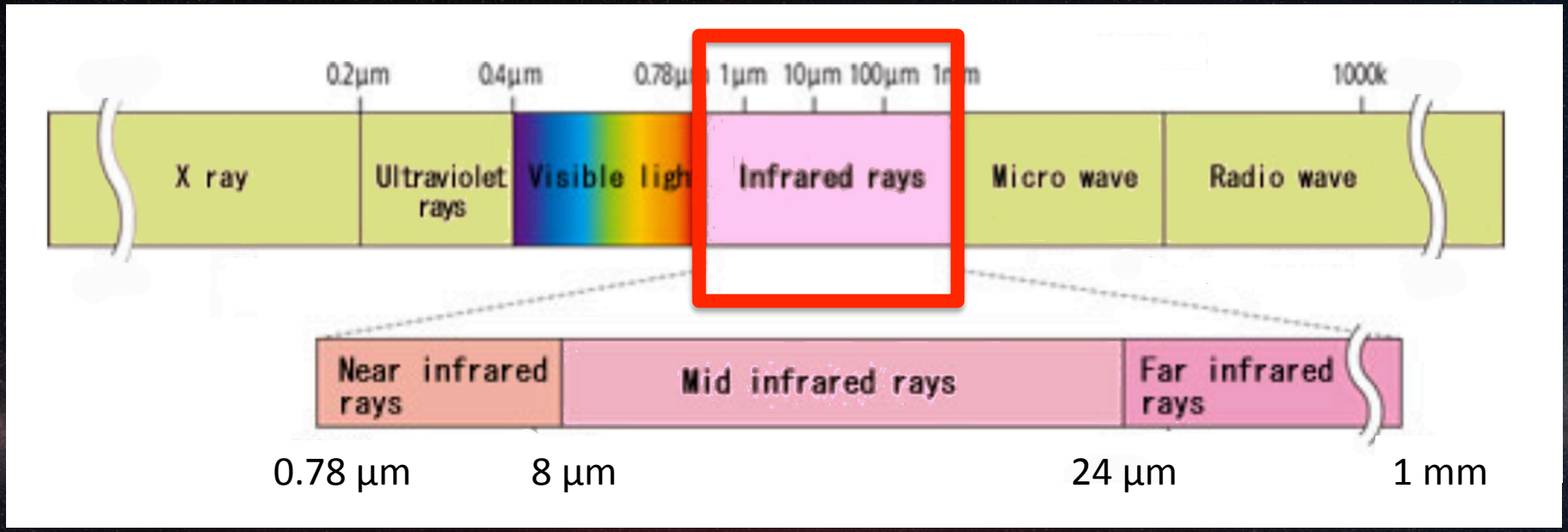
90 %

Telescopes & Antennas

What do we see from the ground ?



Various Infrared telescopes / facilities



IRAS

Spitzer

Herschel

ALMA

Space telescopes

1983

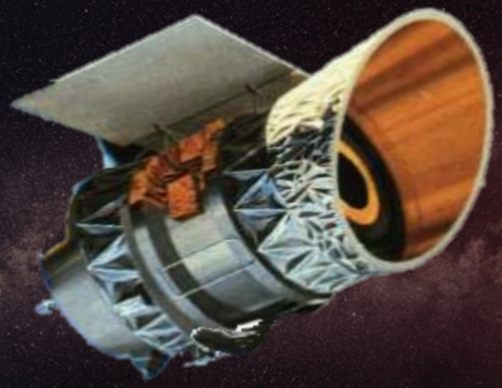
Space telescopes

1983

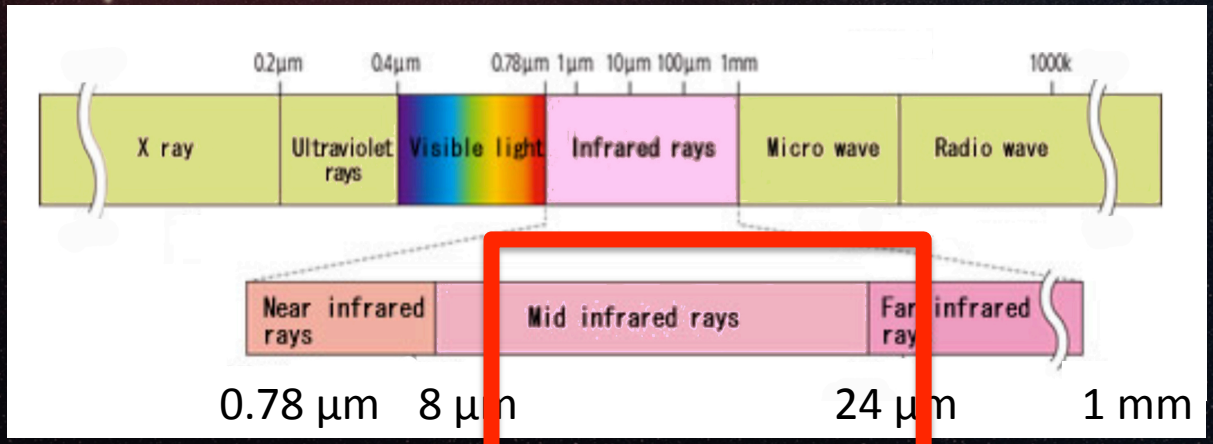
Space telescopes

1983

IRAS



- Full sky survey
- Mirror diameter: 0.57m
- Mission of 10 months
- Looking at 12 to 100 µm



Space telescopes

1983

↓

2003

Space telescopes

Space Shuttle Columbia disaster

1983

↓

2003

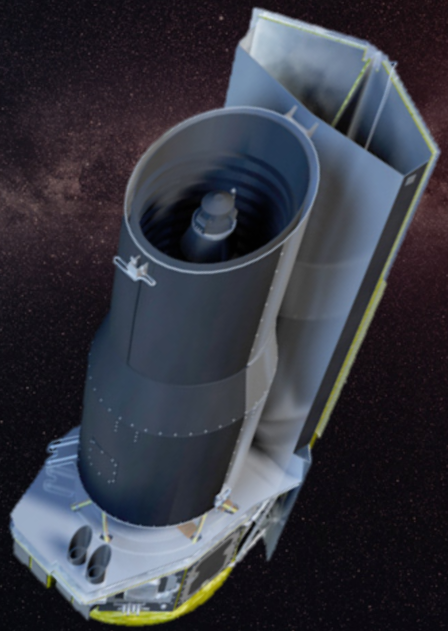
Space telescopes

1983

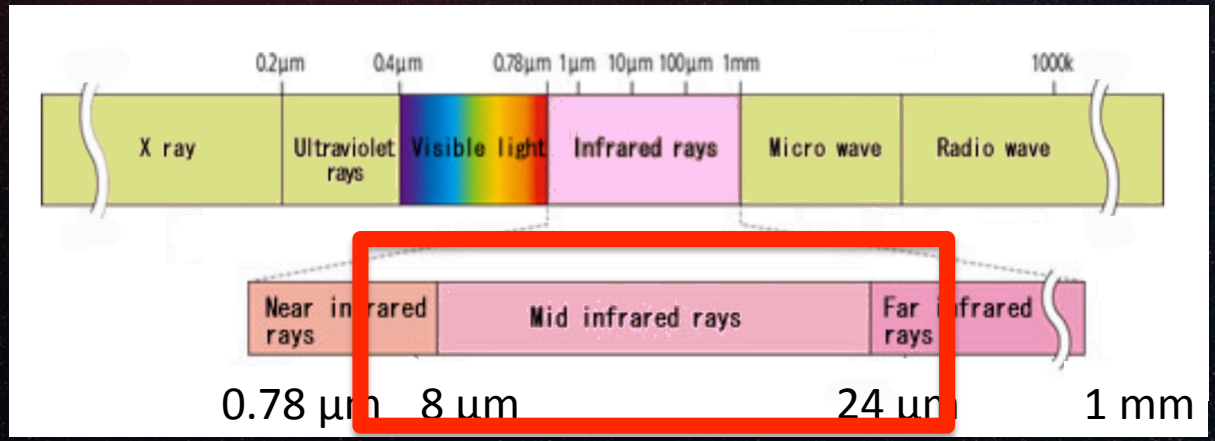
↓

2003

Spitzer



- Build by NASA
- Diameter: 0.85m
- Looking at 3.6 to 160 µm
- Warm-Spitzer phase
- > 1 billion $



Space telescopes

Space telescopes

Herschel

- Built by ESA
- Diameter: 3.5m !
- Looking at 70 to 500 µm
- Mission: 3 years

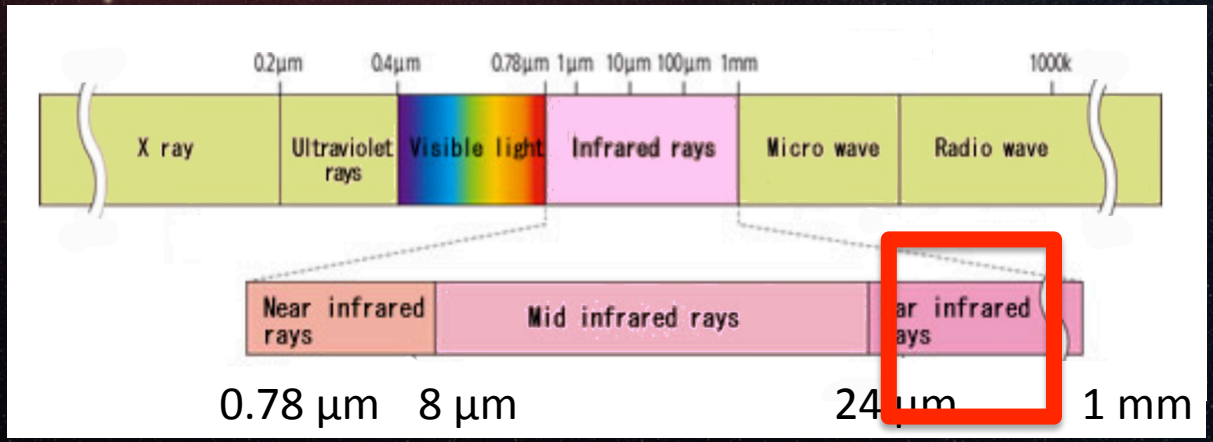
1983

↓

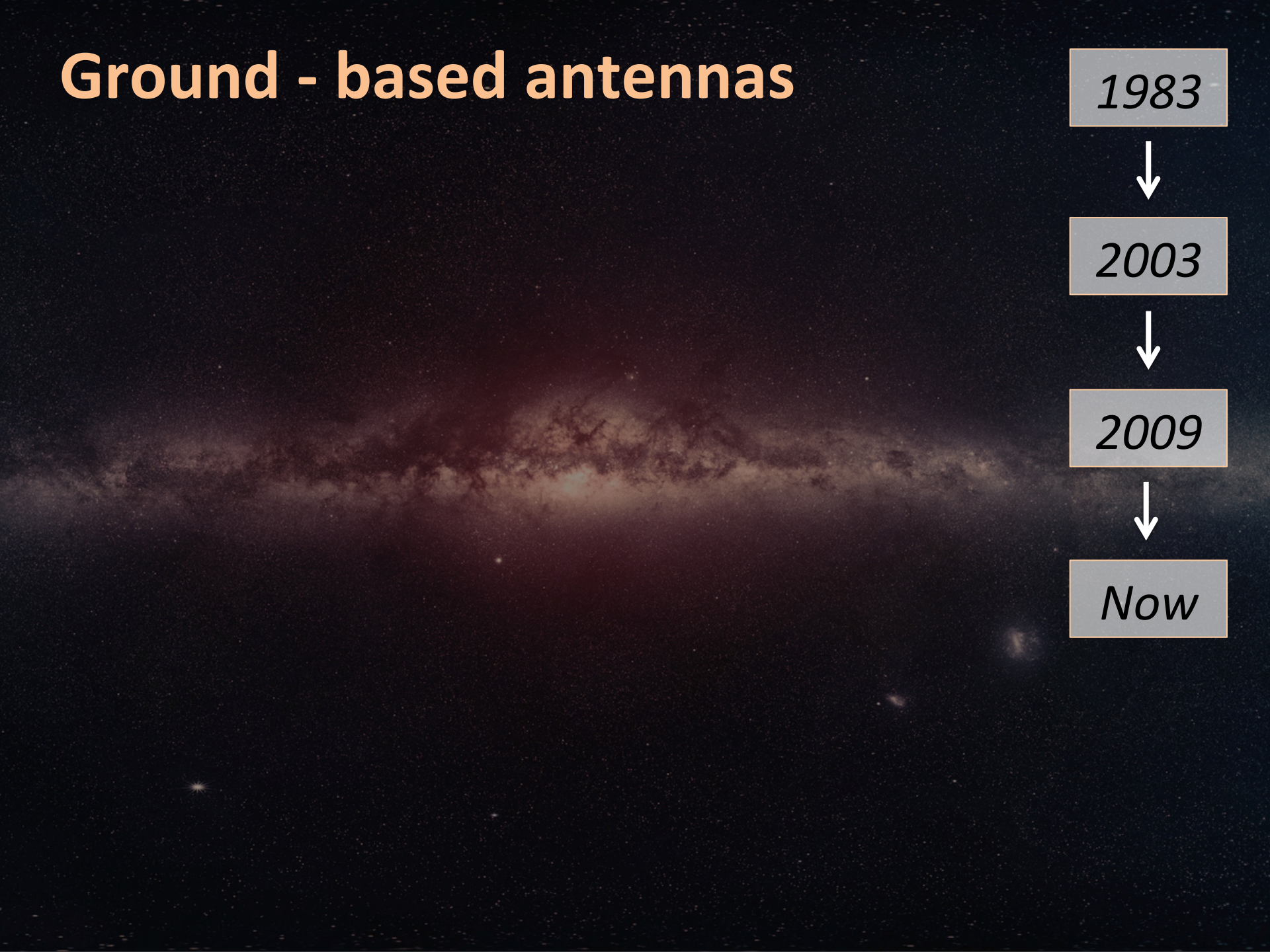
2003

↓

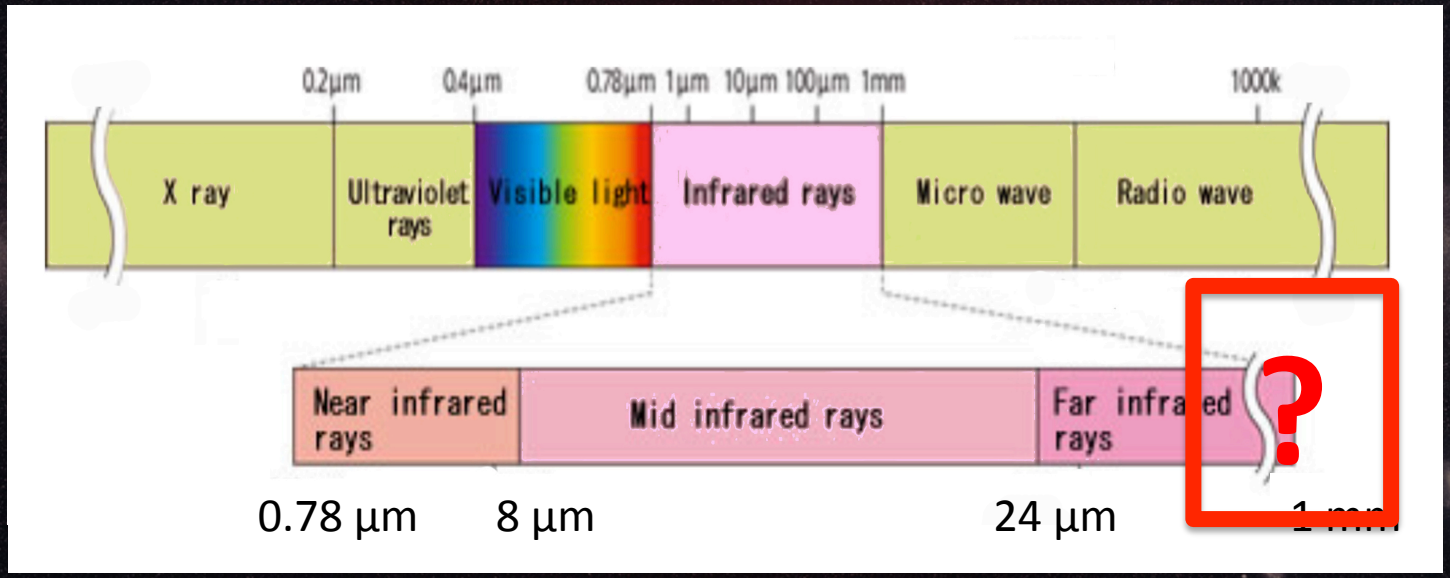
2009



Ground - based antennas



Ground - based antennas



1983

↓

2003

↓

2009

↓

Now

Ground - based antennas

ALMA

1983

↓

2003

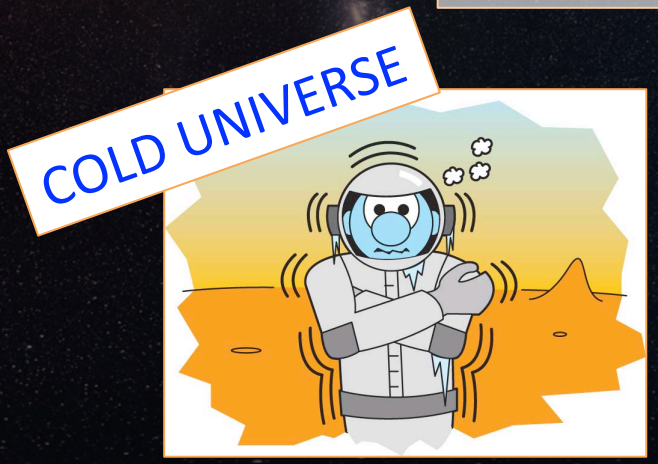
↓

2009

↓

Now

- International consortium
- > 60 antennas of 12m + 7m antennas
- Beyond the infrared wavelength



Ground - based antennas

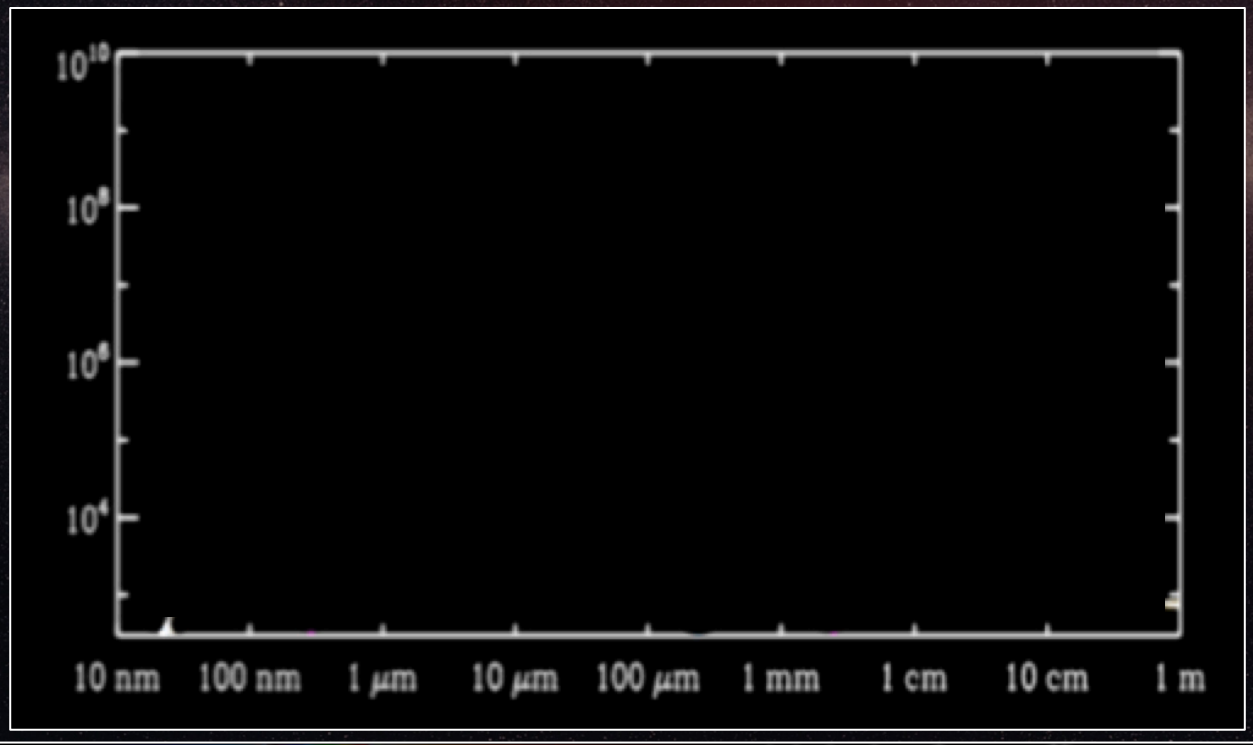
ALMA - Adjustable resolution
→ great details on the structure

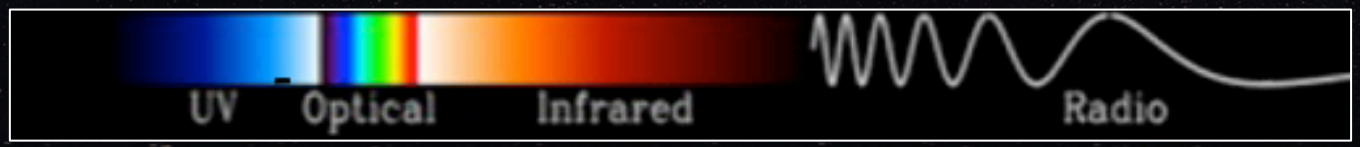
On the Chajnantor plateau

Variation of luminosity

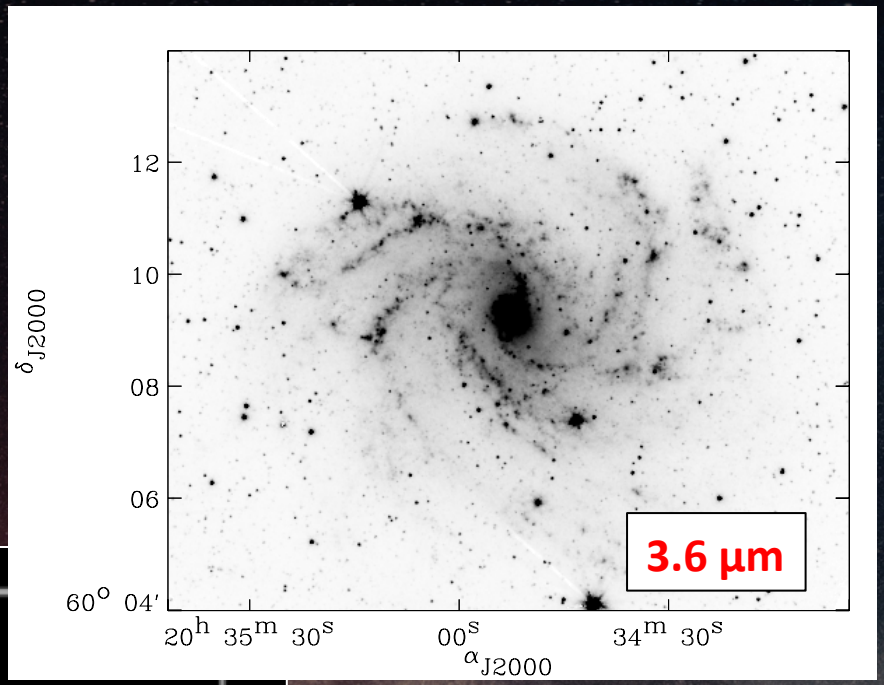
with color

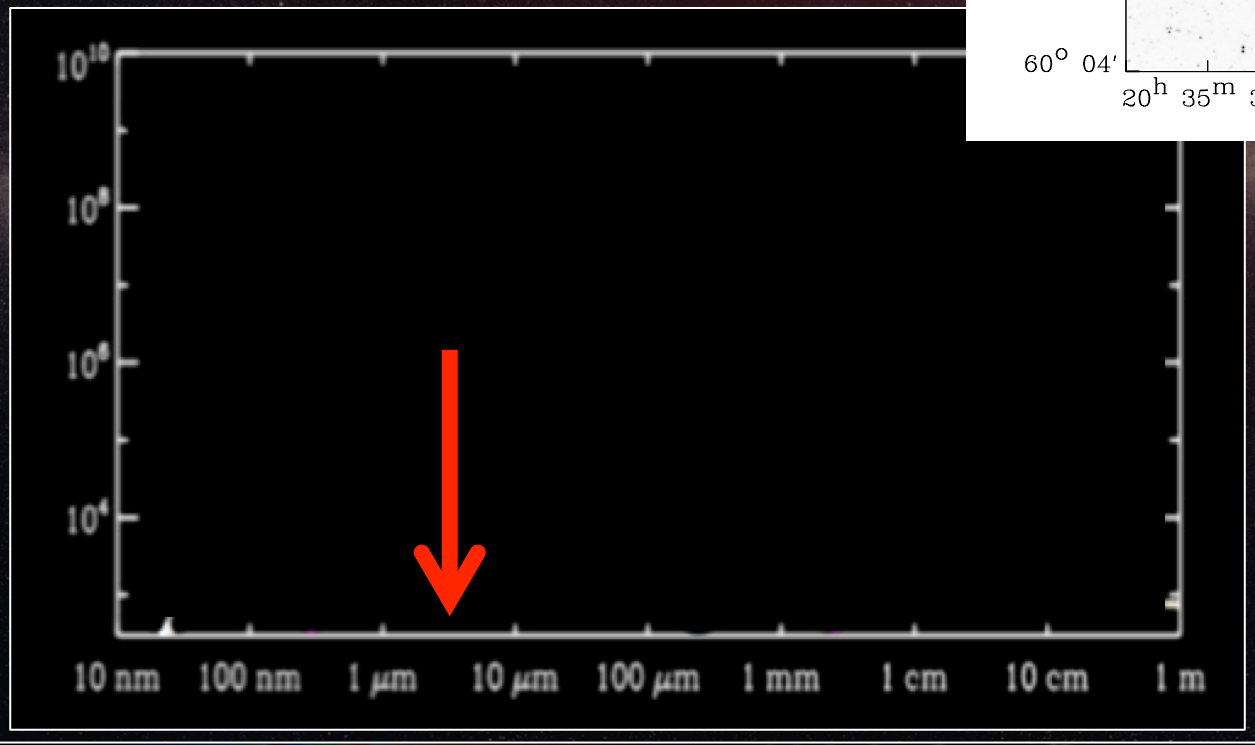
Variation of the luminosity with color

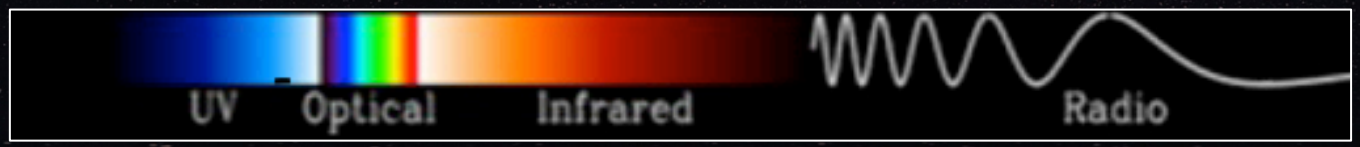




Variation of the luminosity with color







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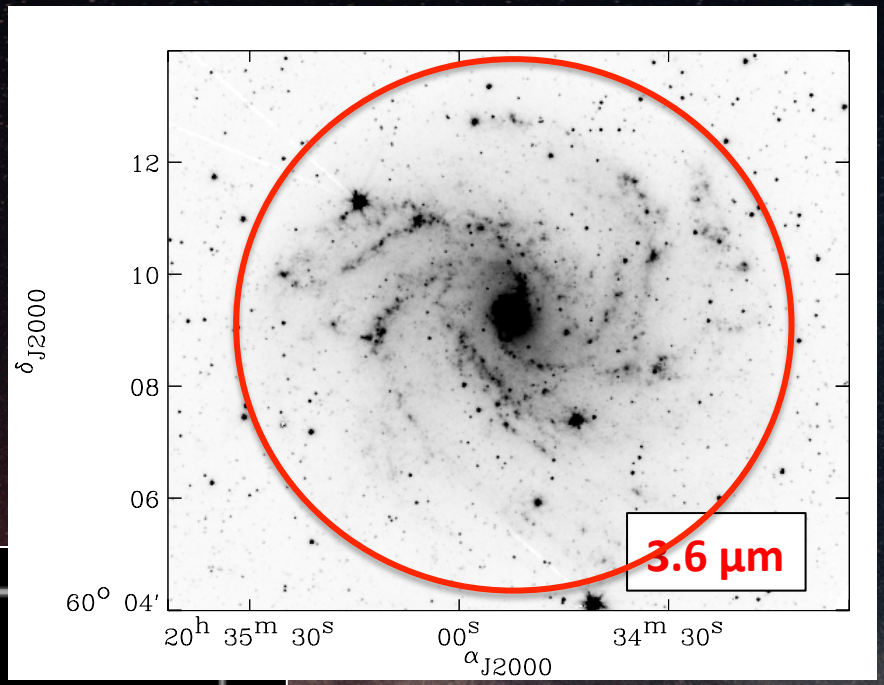

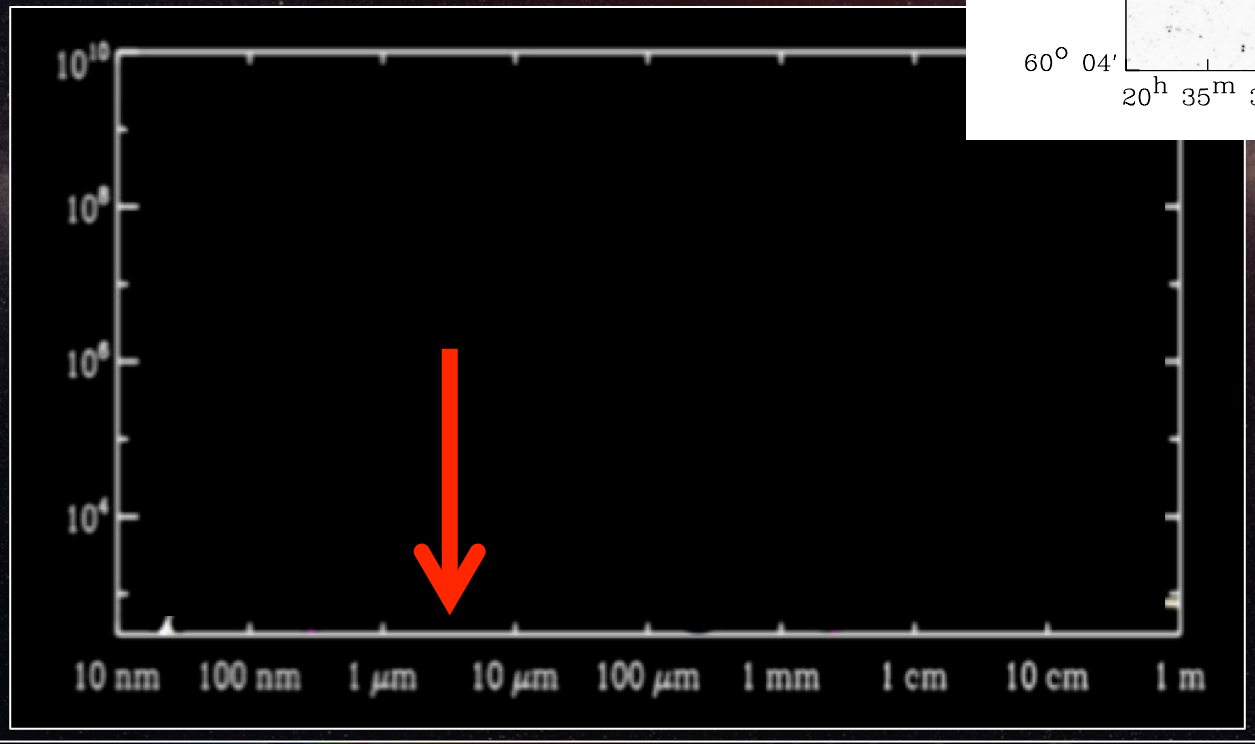

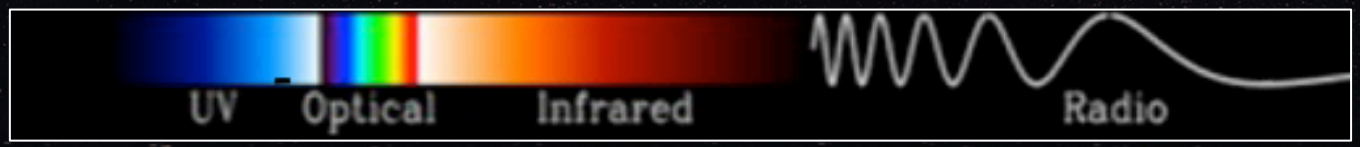

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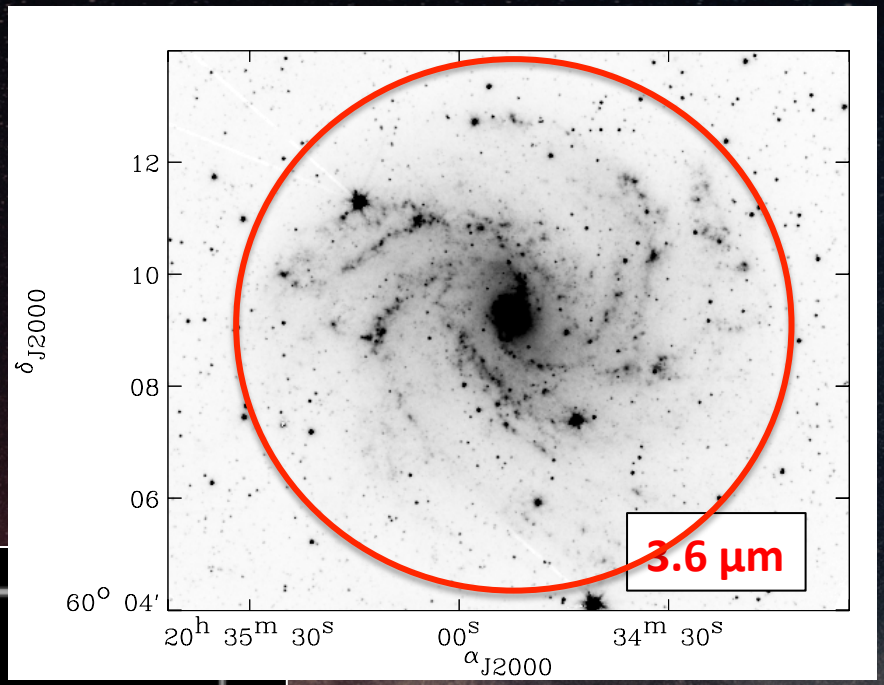

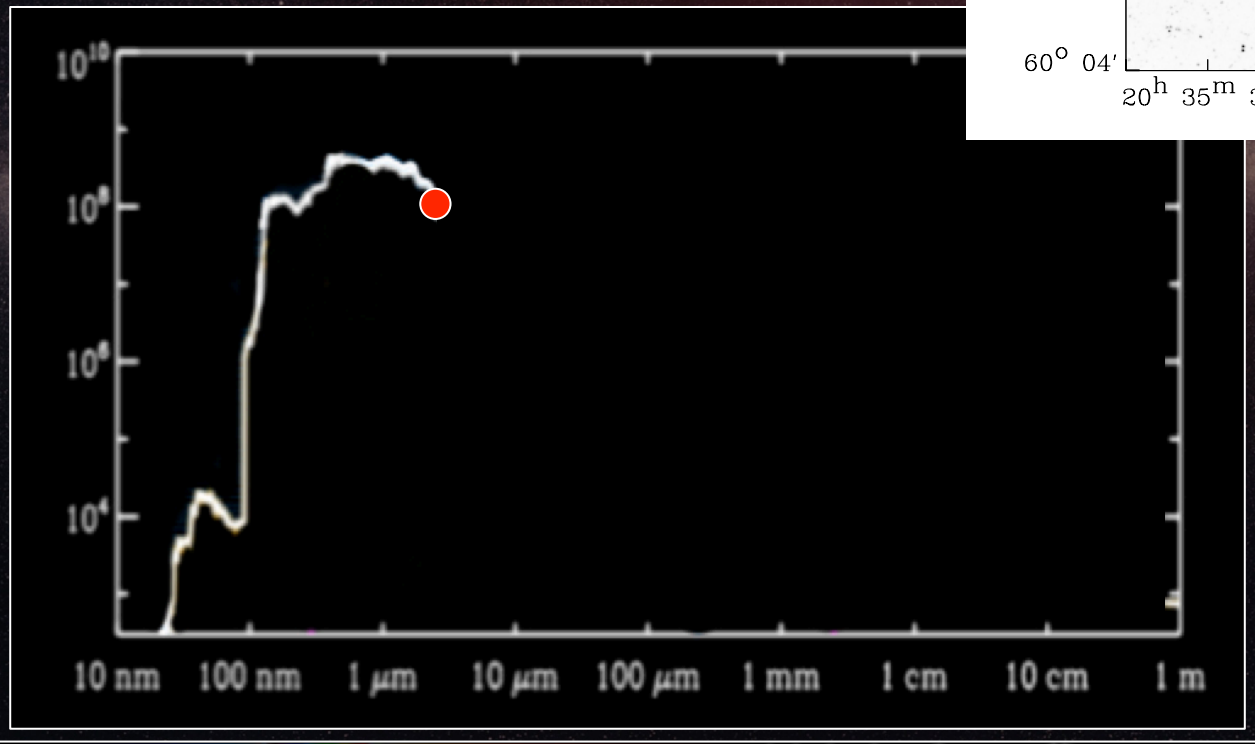

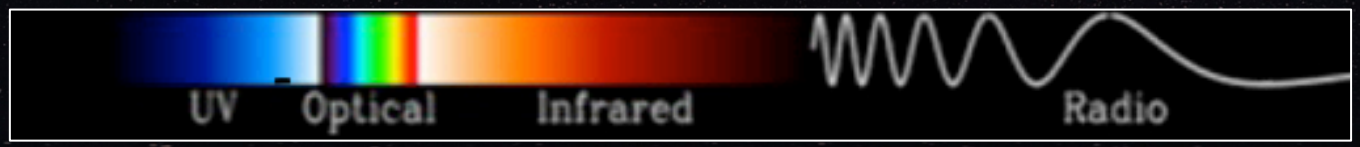

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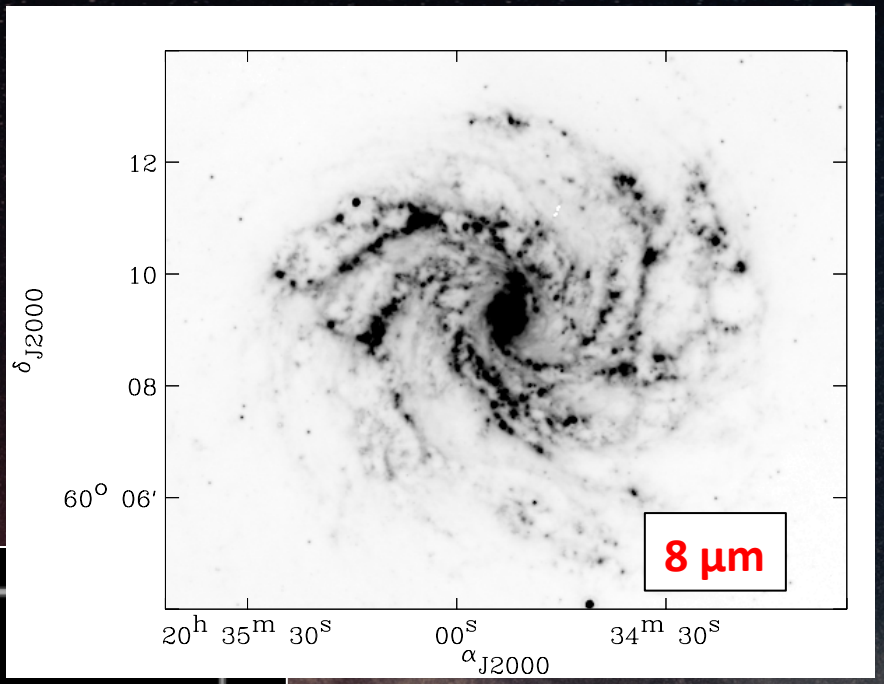

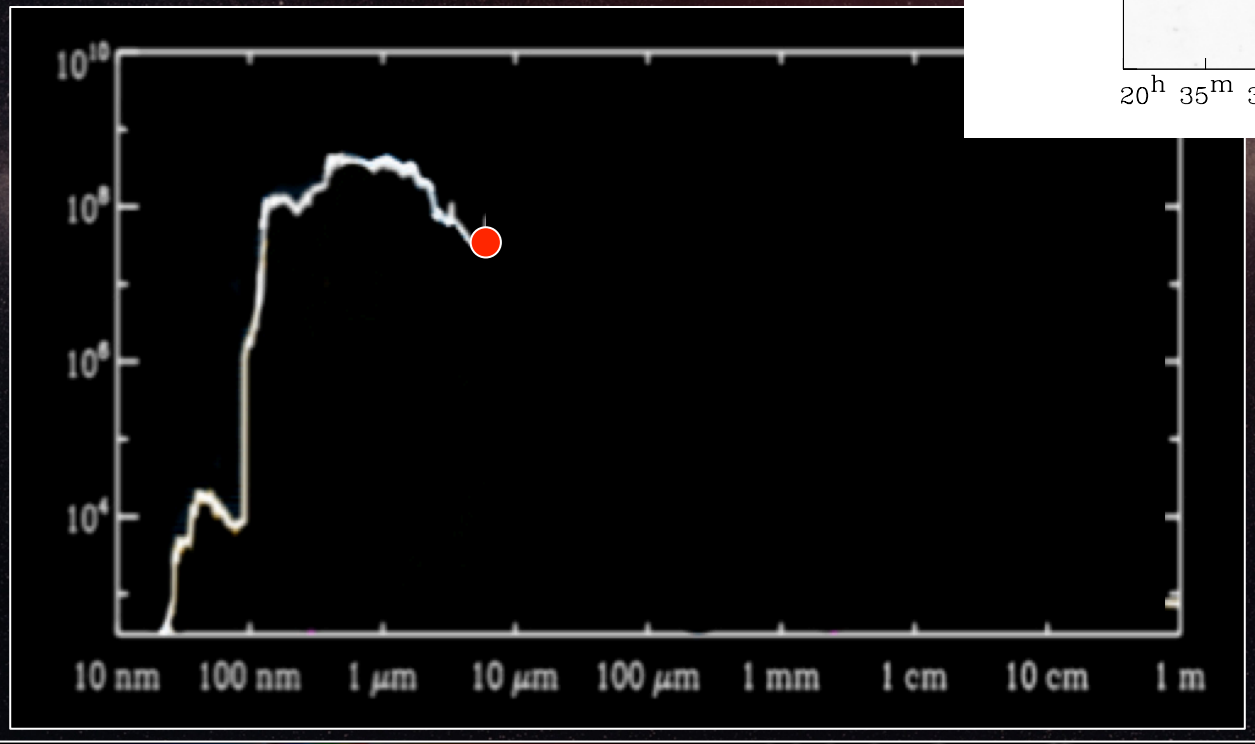

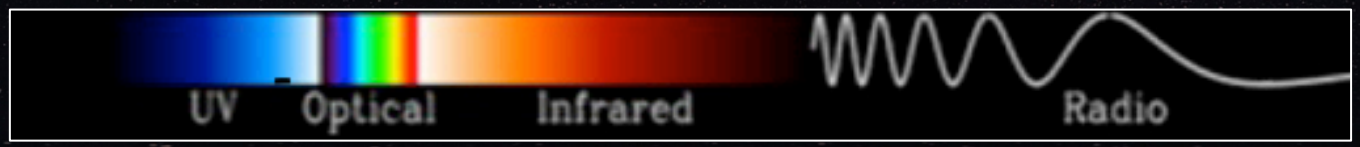

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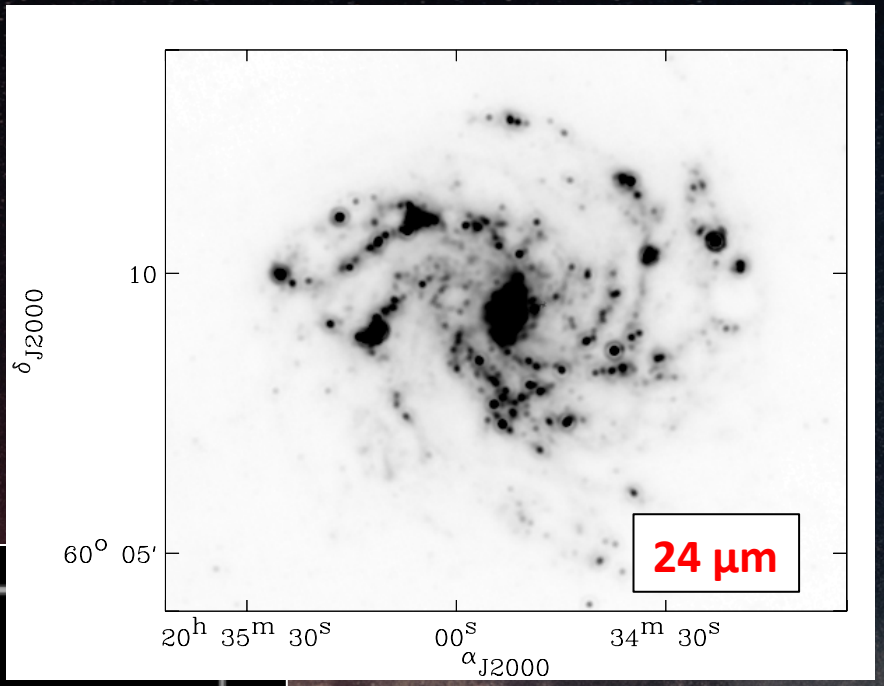

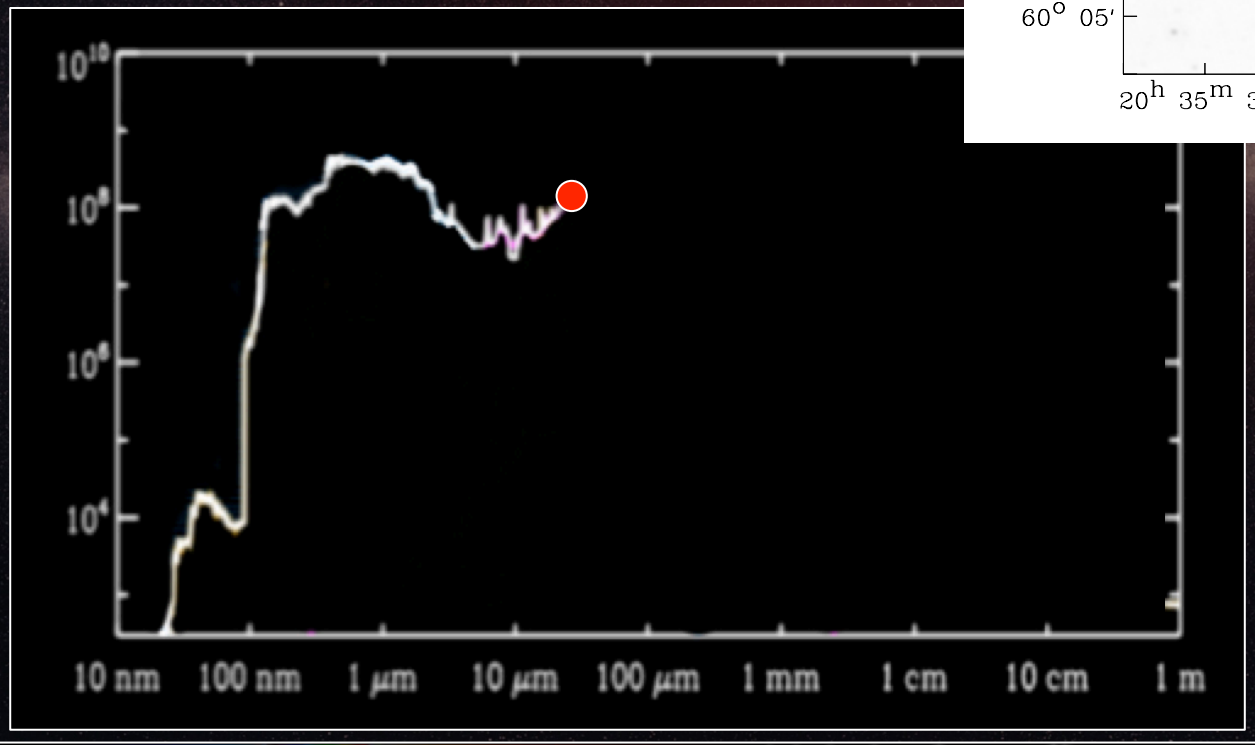

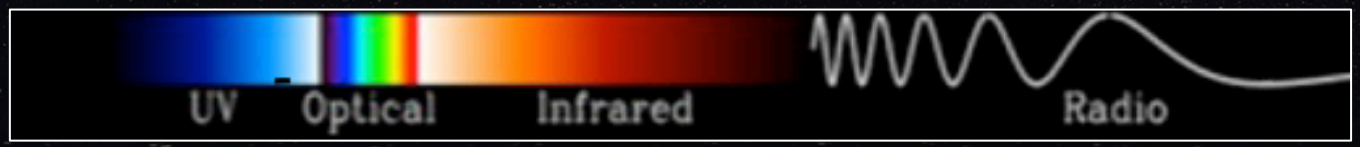

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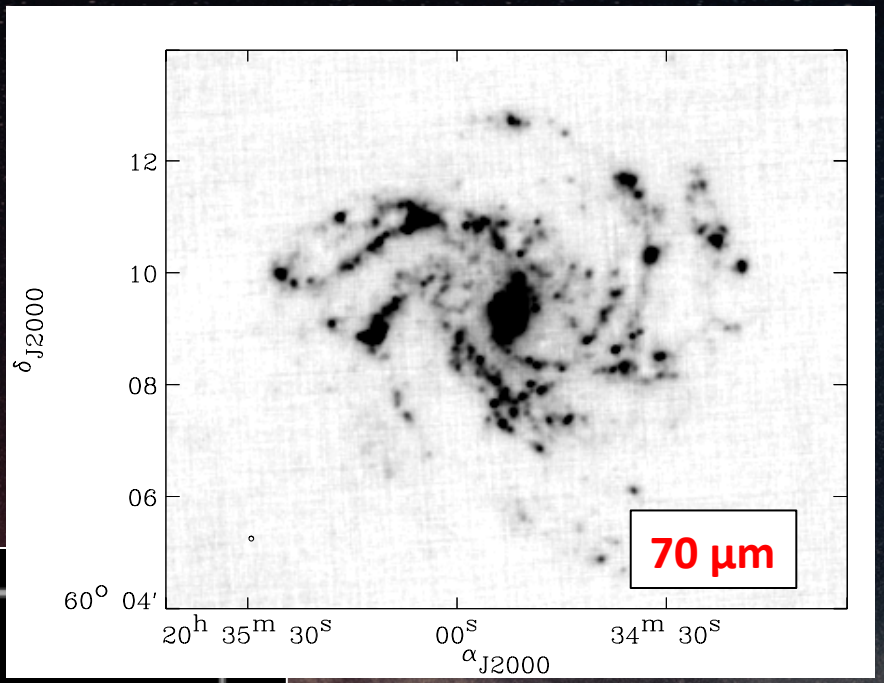

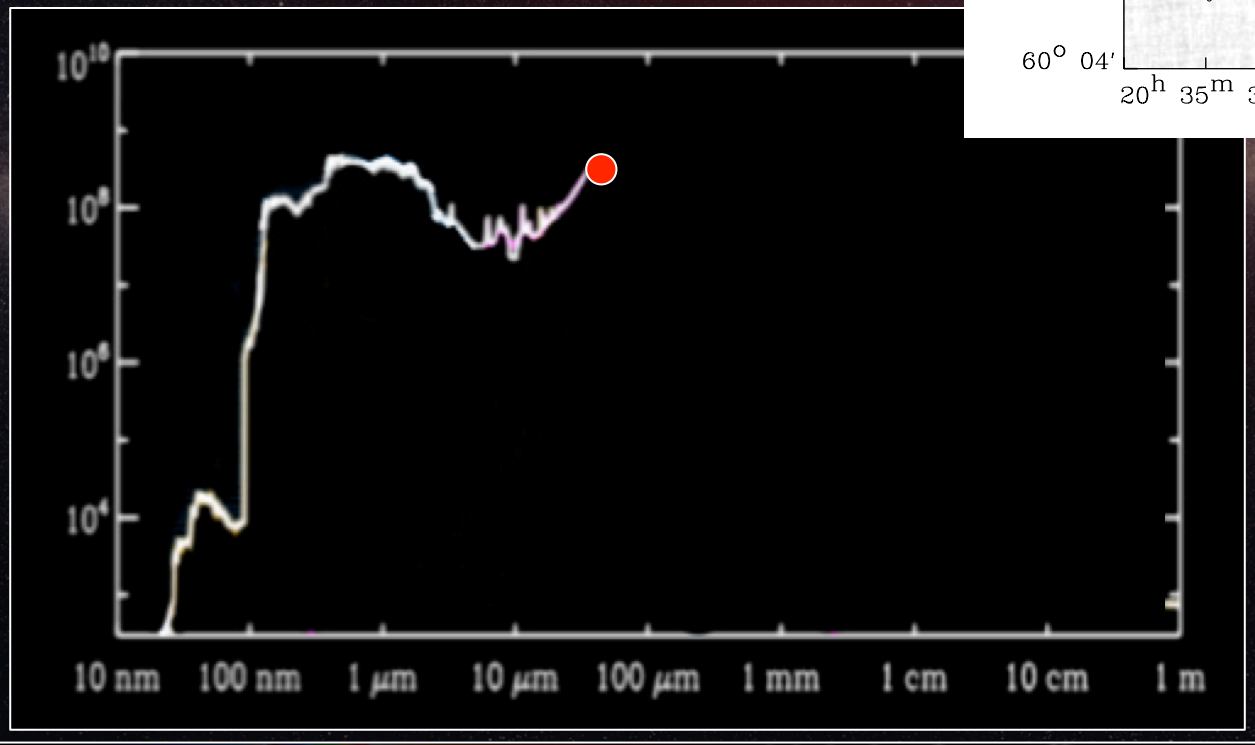

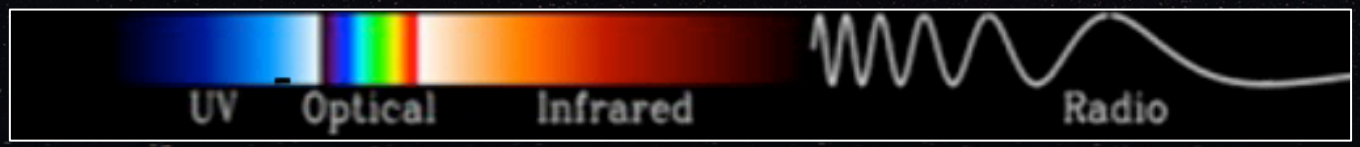

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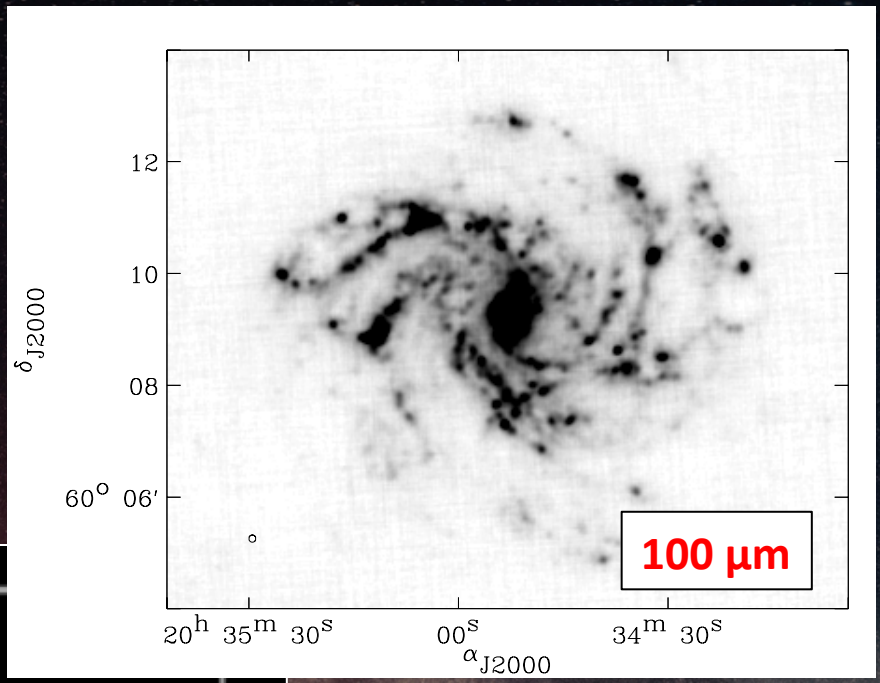

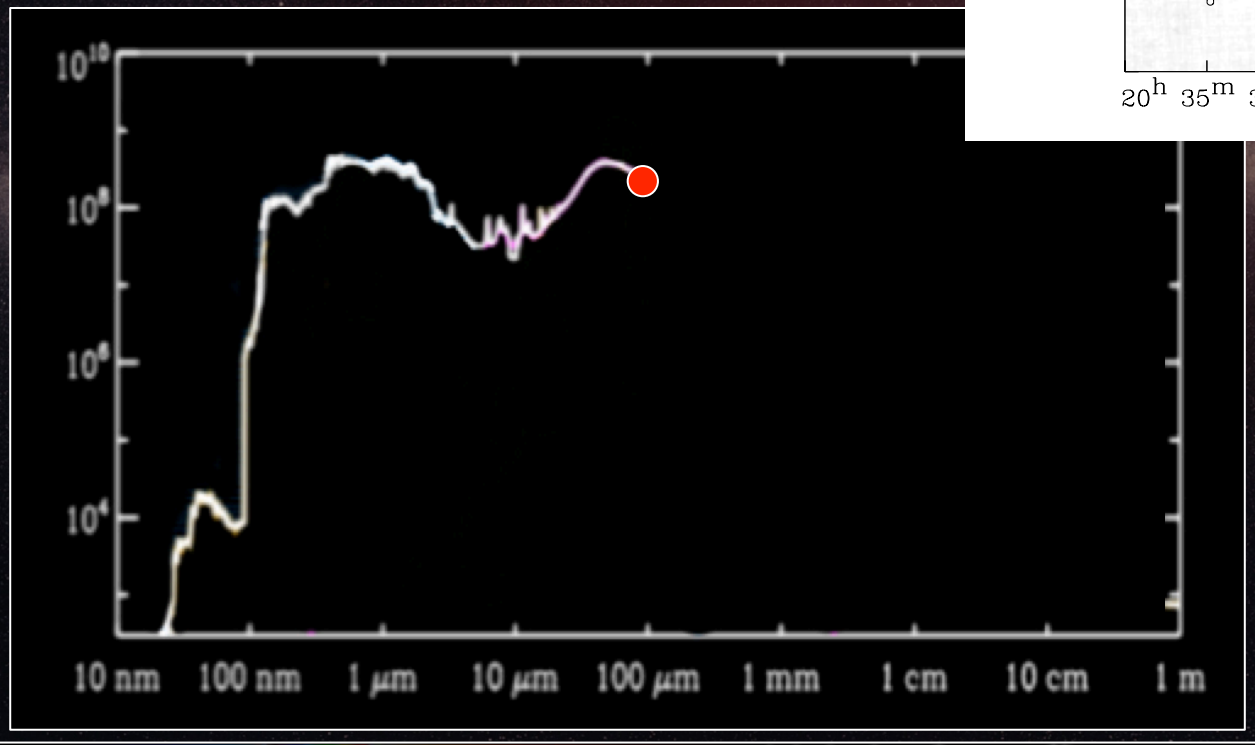

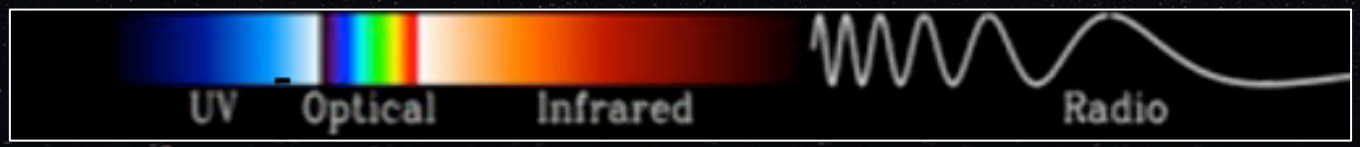

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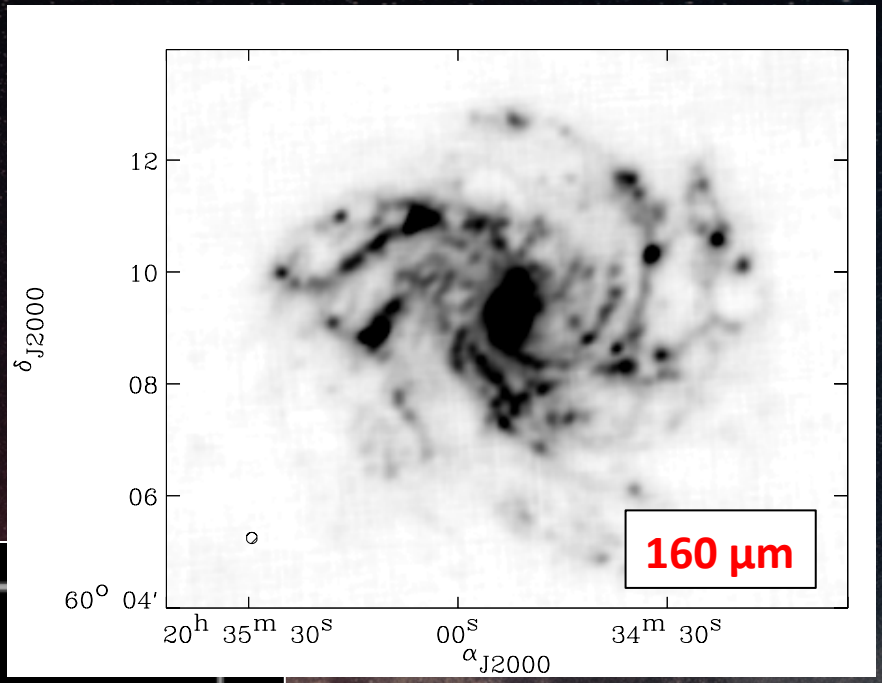

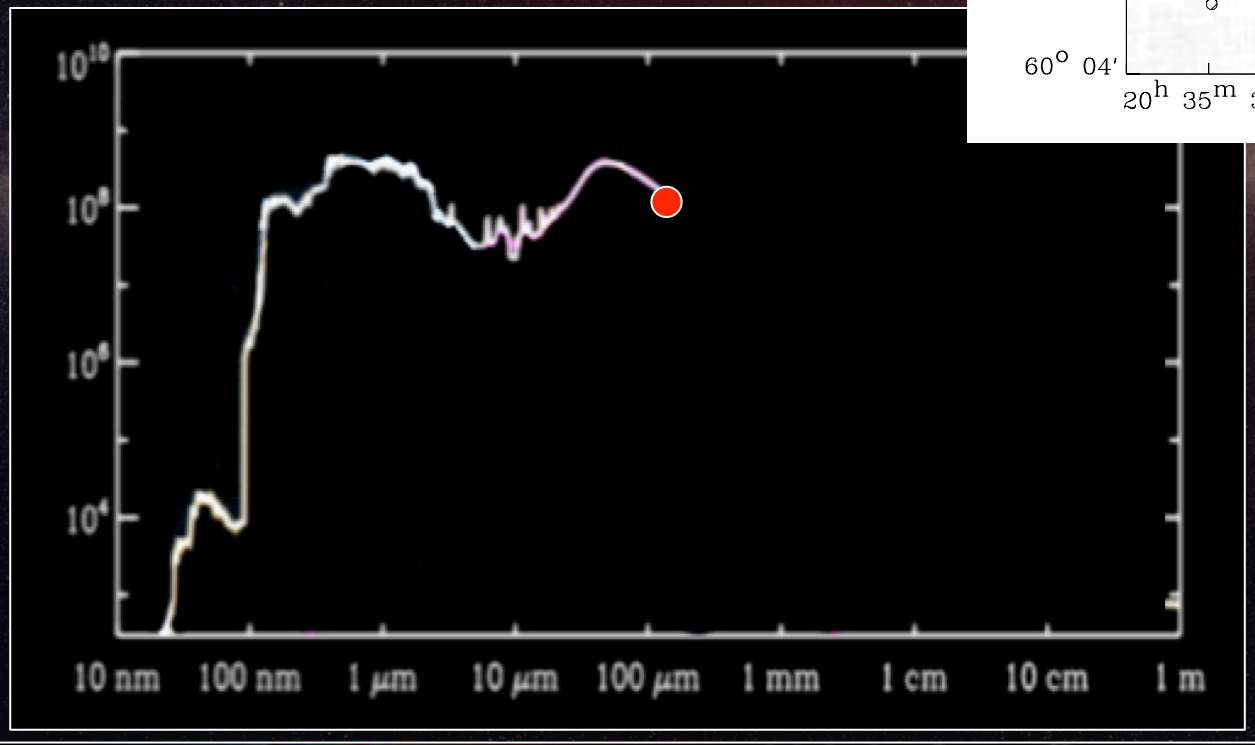

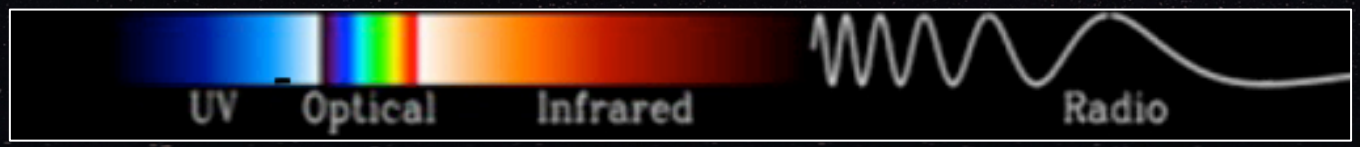

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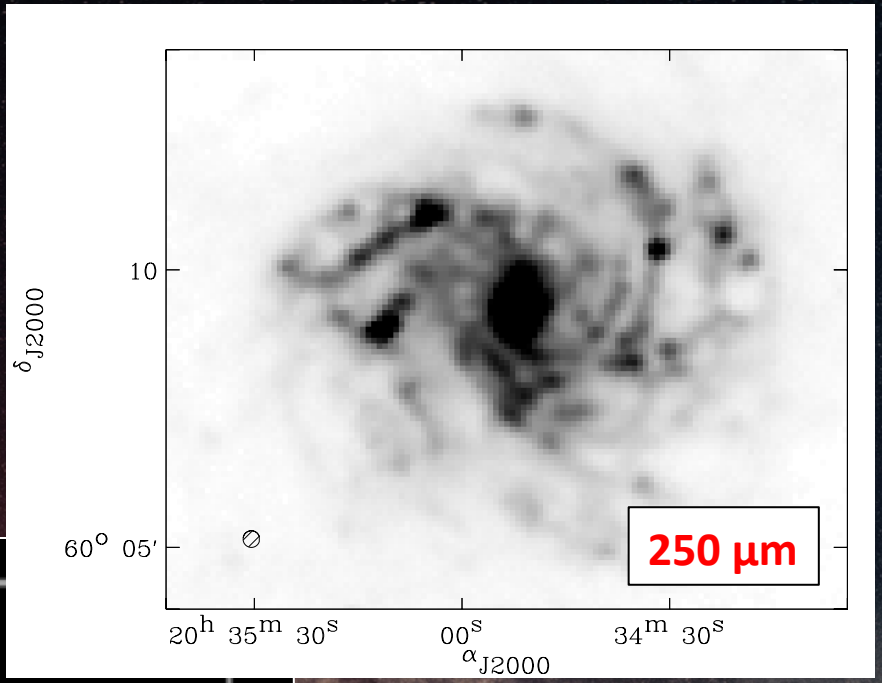

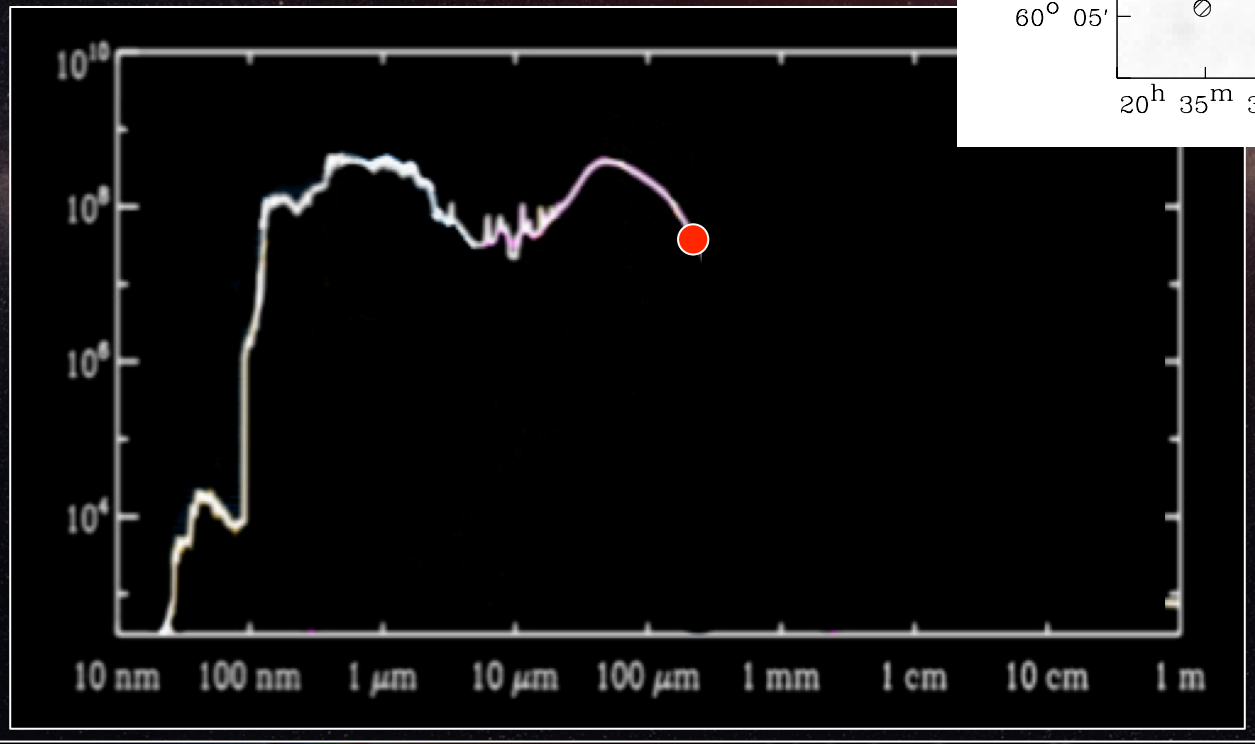

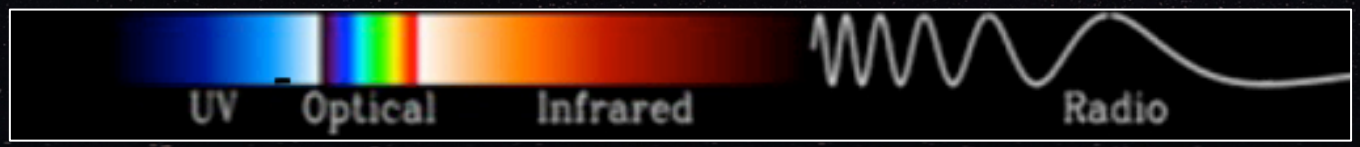

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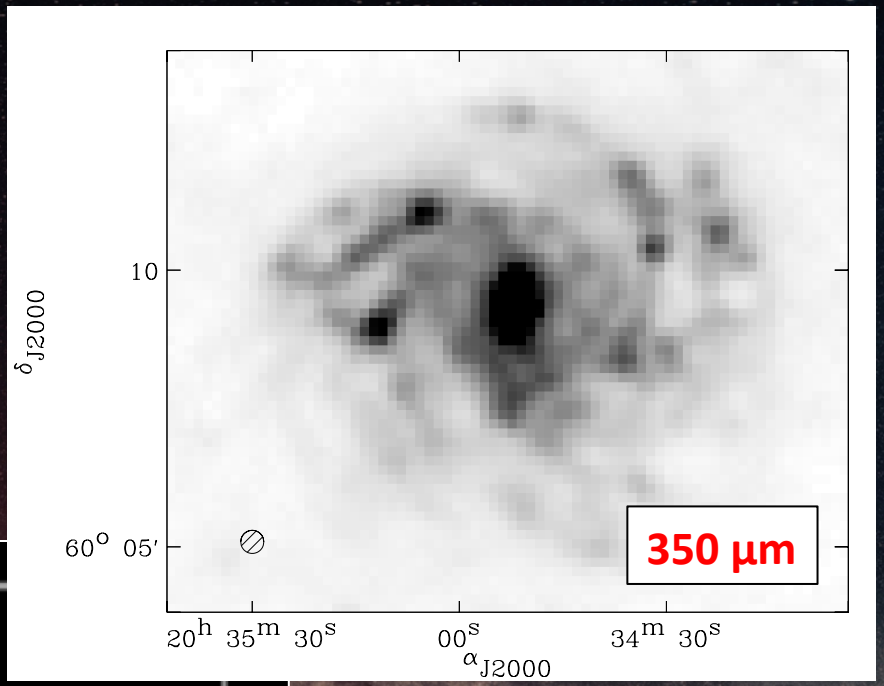

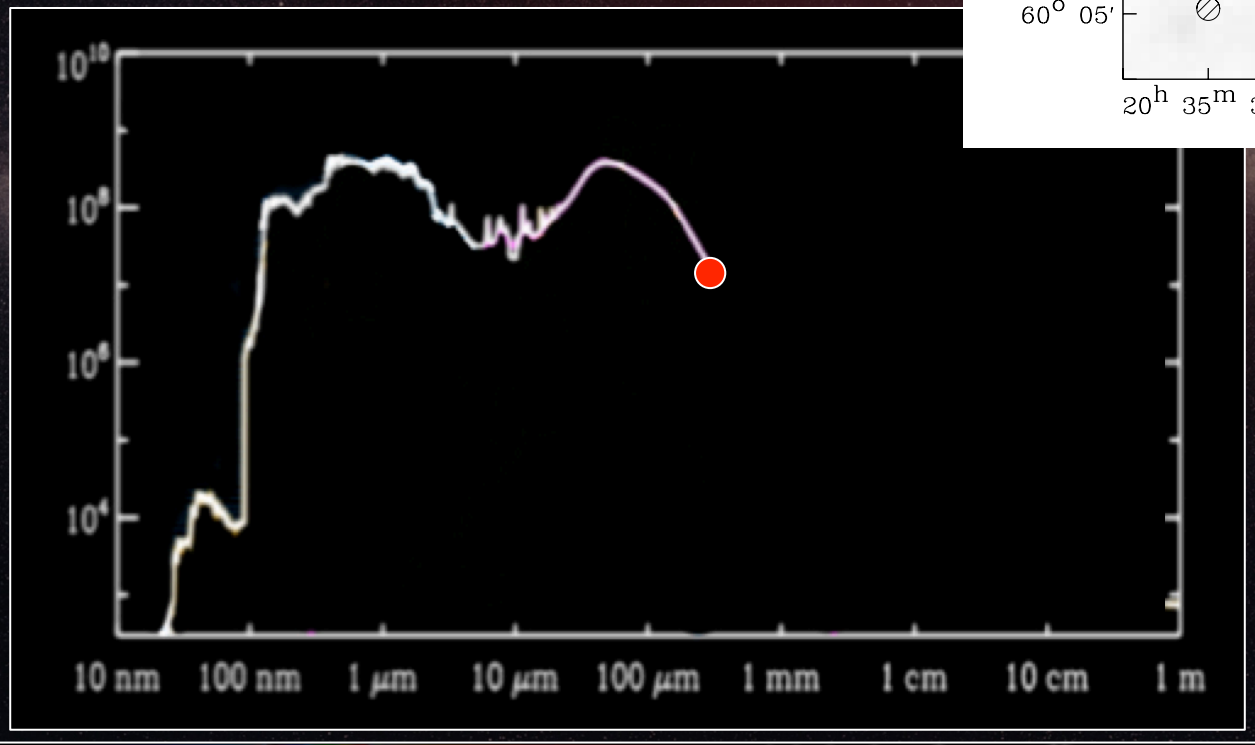

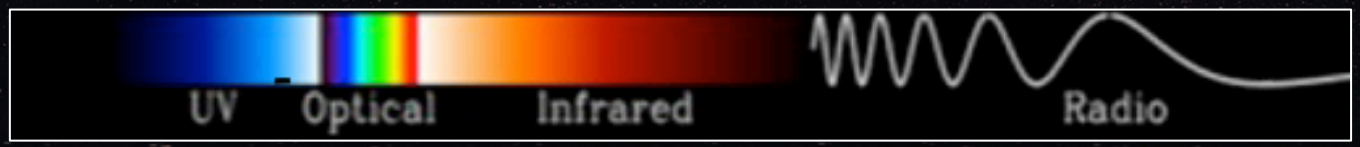

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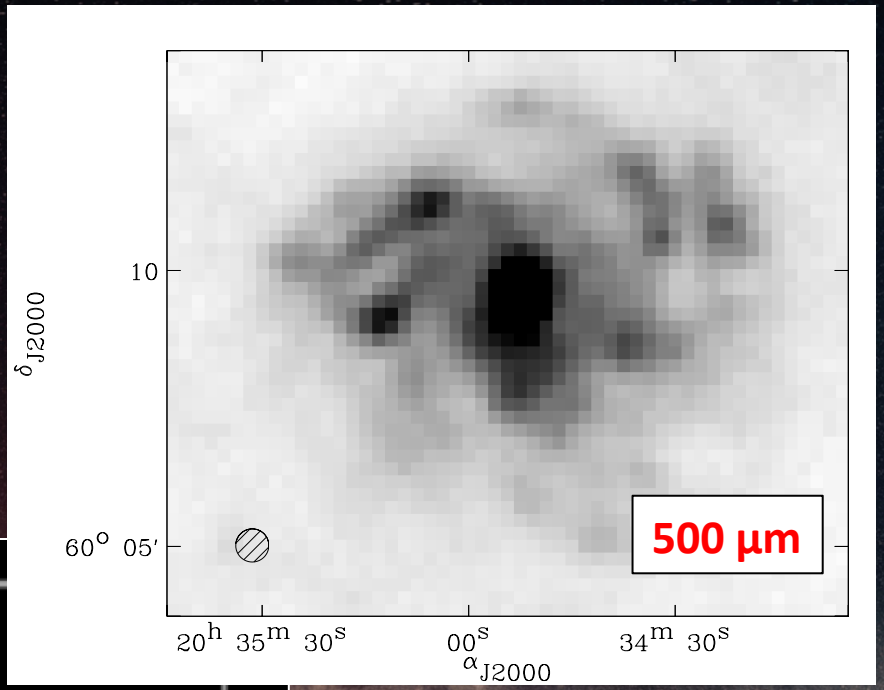
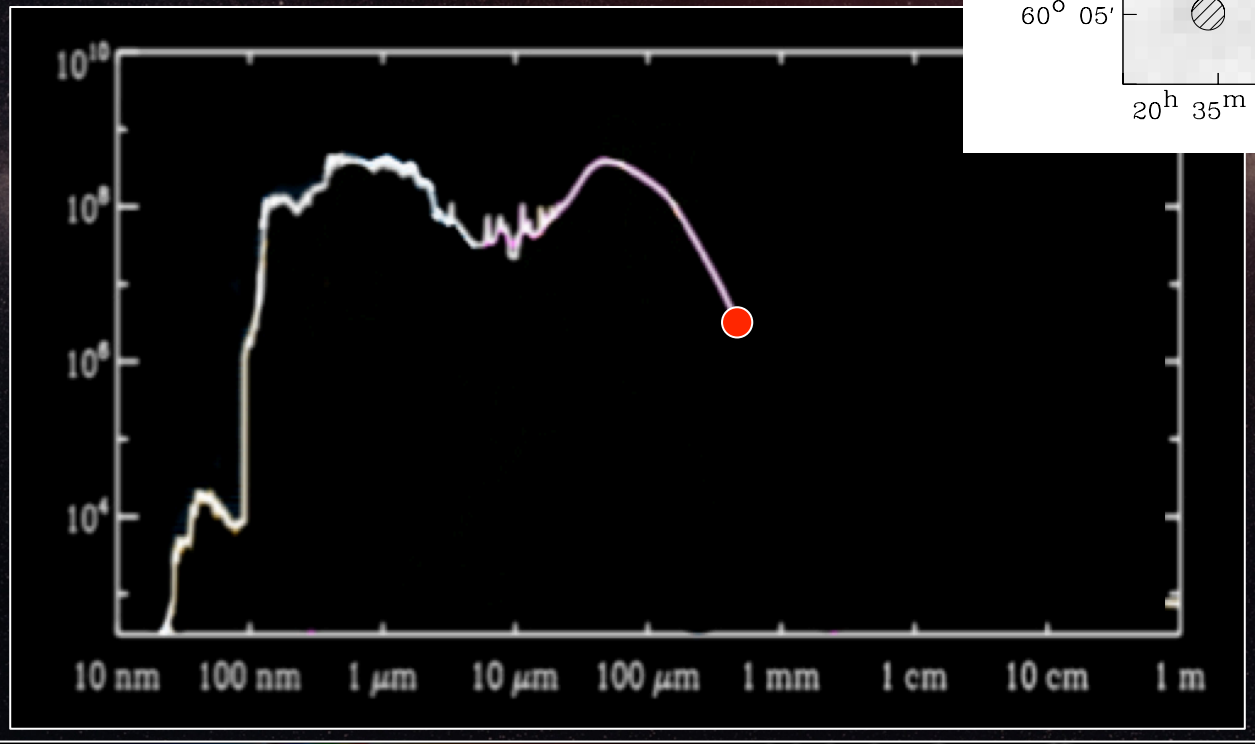
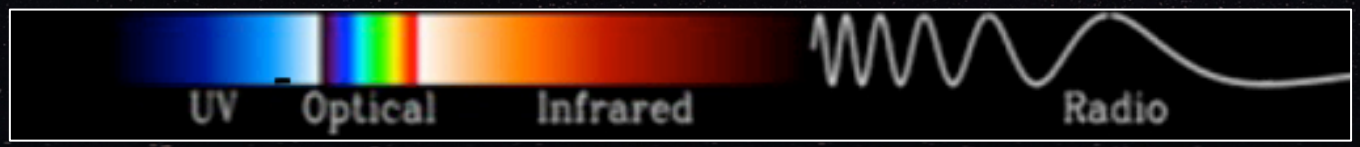
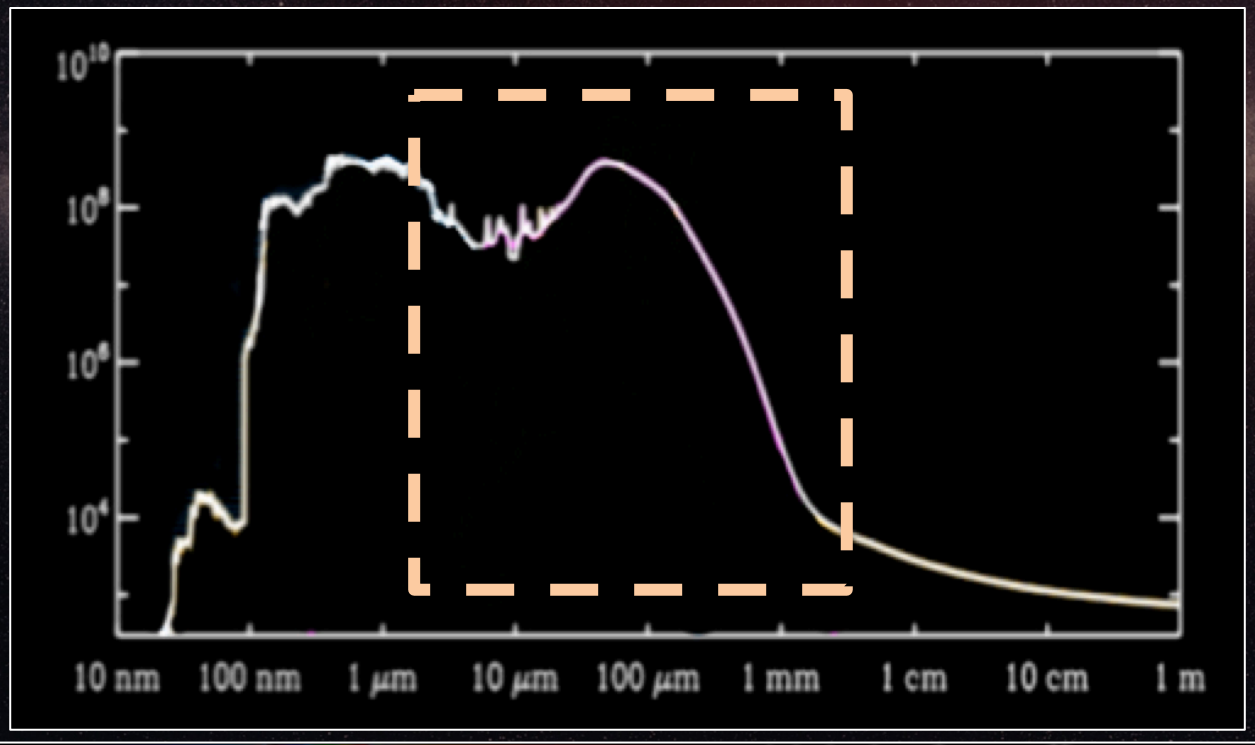
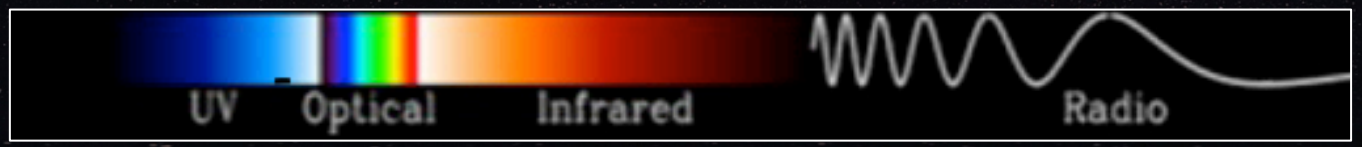






That is what we are going to dissect together now





Finished product

Ingredients + recipe

Using the energy distribution to learn more about the dust properties

Finished product

Ingredients + recipe

- Size

- Temperature

- Composition

Finished product

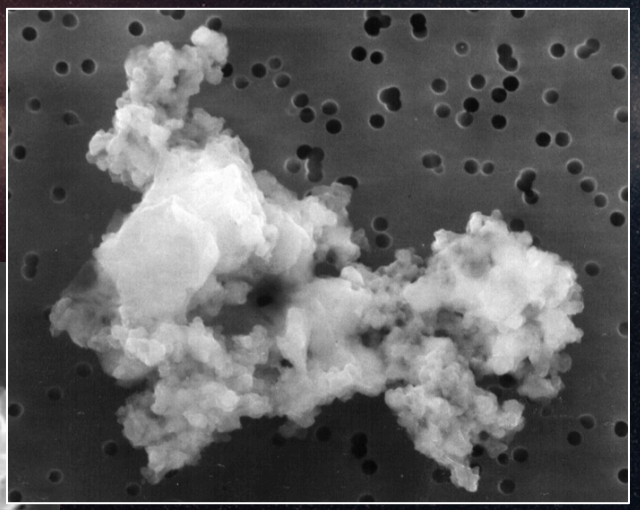
Ingredients + recipe

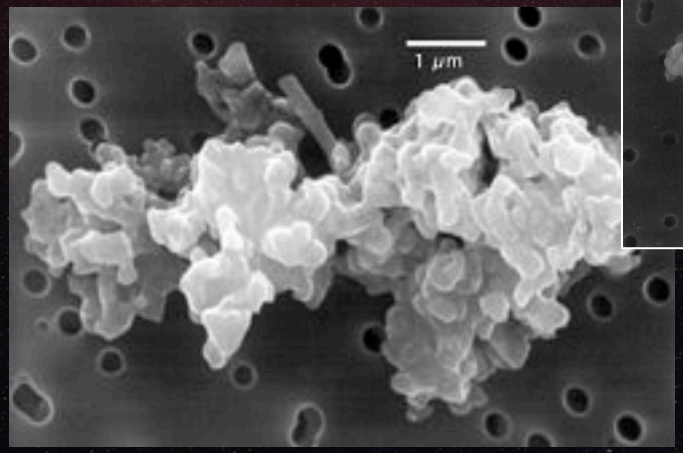
- ***Size***
- ***Temperature***
- ***Composition***

Dust comes in all shapes and sizes

Spherical grains are rare !

→ rather complex aggregates



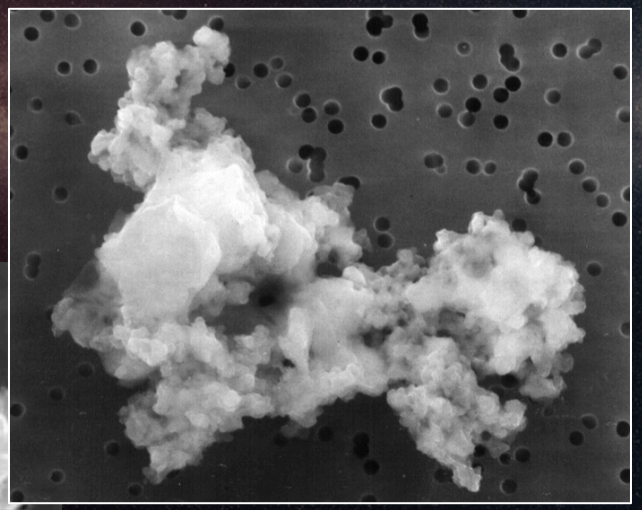


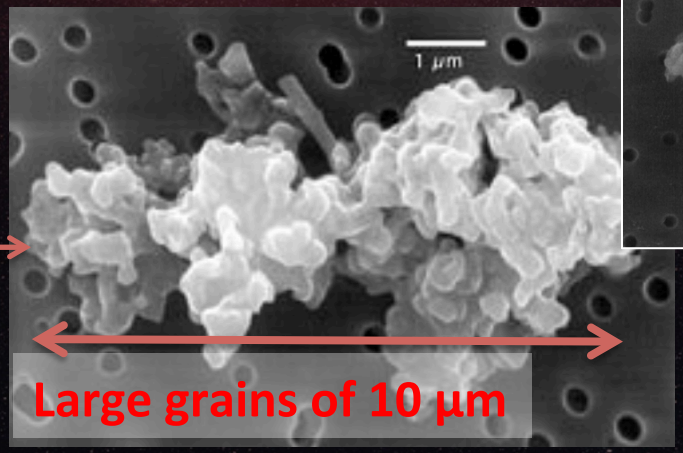
Dust particles collected from the stratosphere

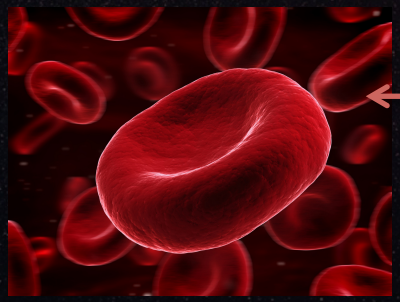
Dust comes in all shapes and sizes

Spherical grains are rare !

→ rather complex aggregates



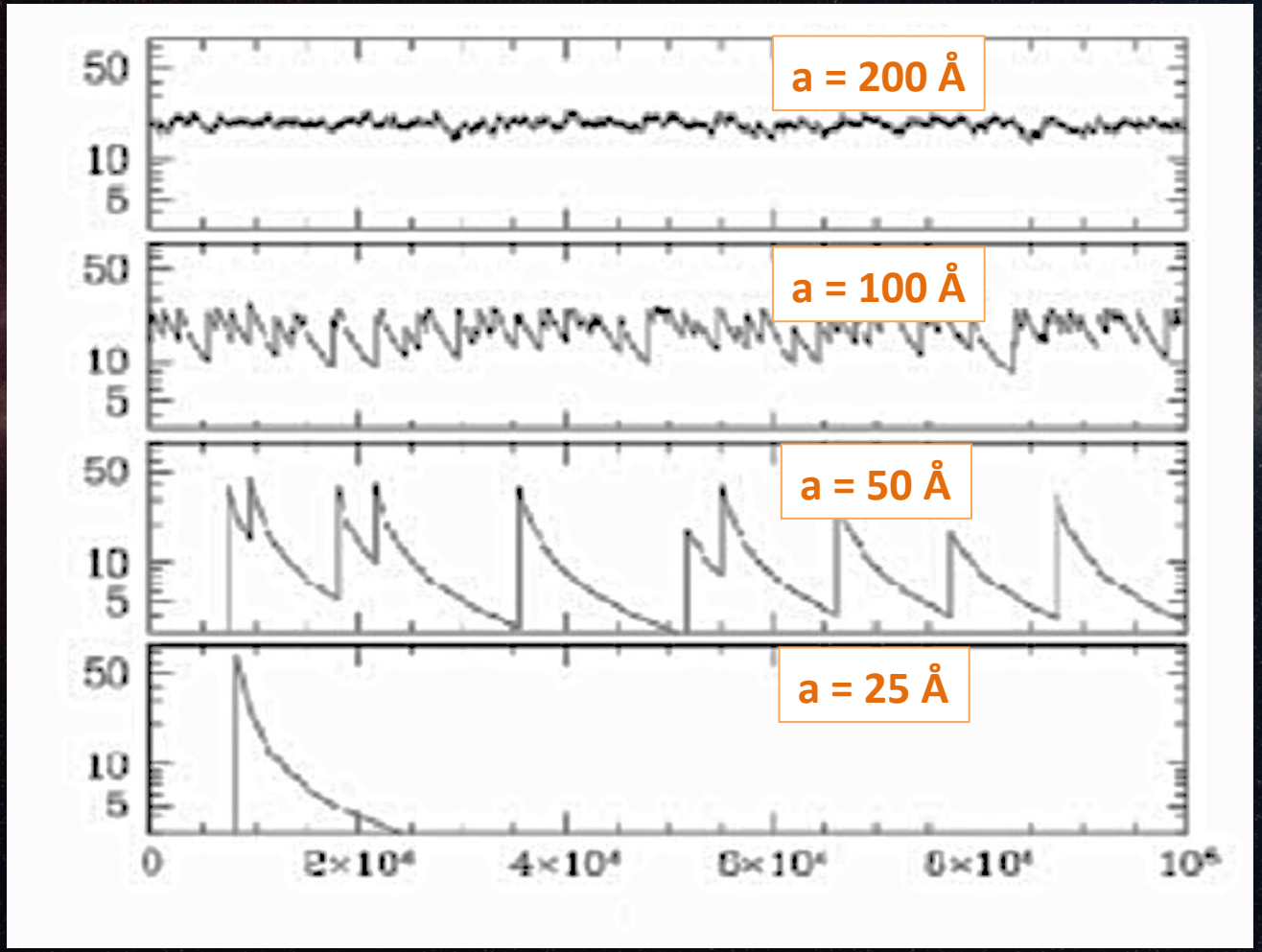




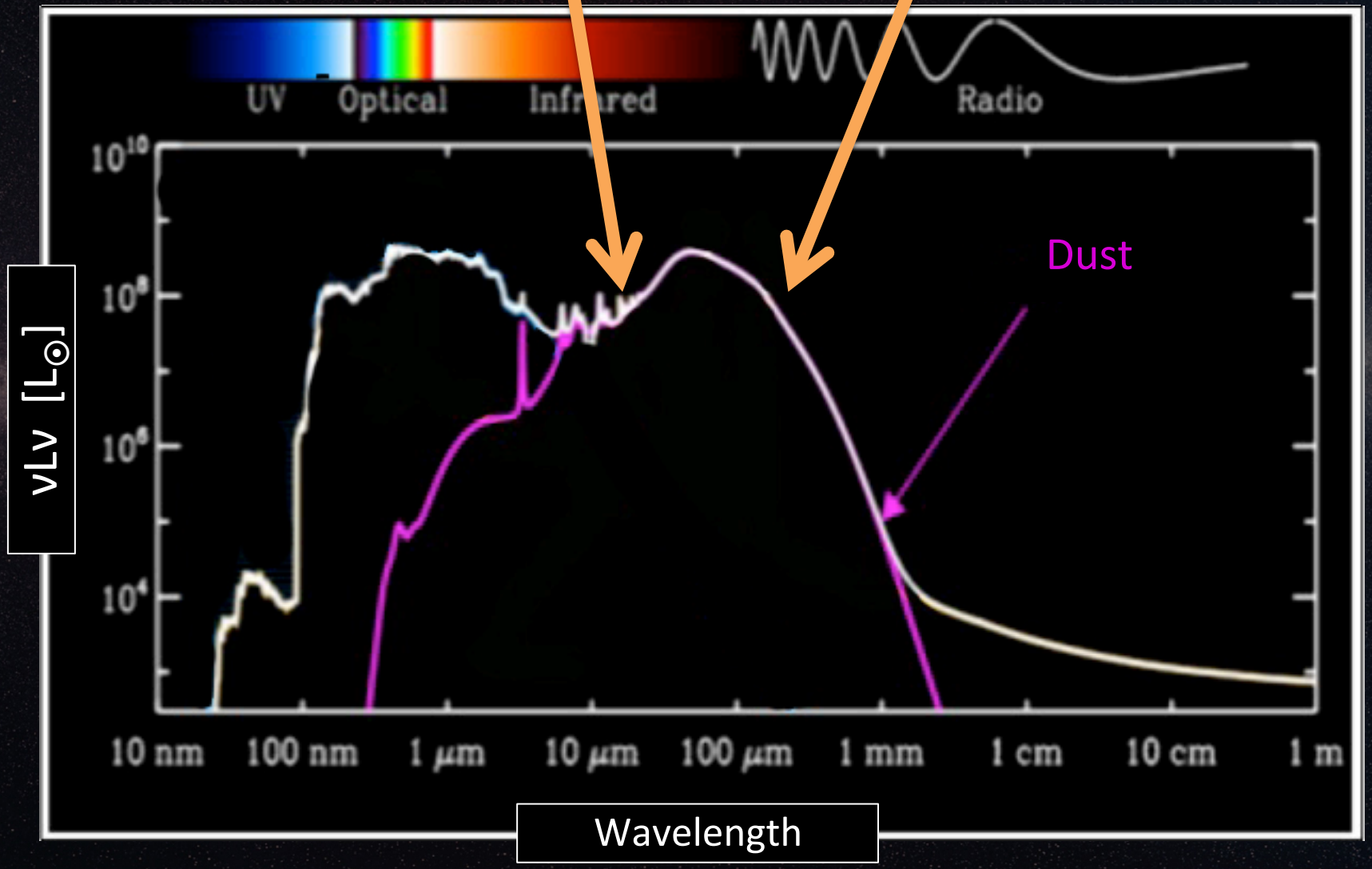
Large grains of 10 µm

Dust particles collected from the stratosphere

and react differently to the radiation



(Very) small grains Large grains



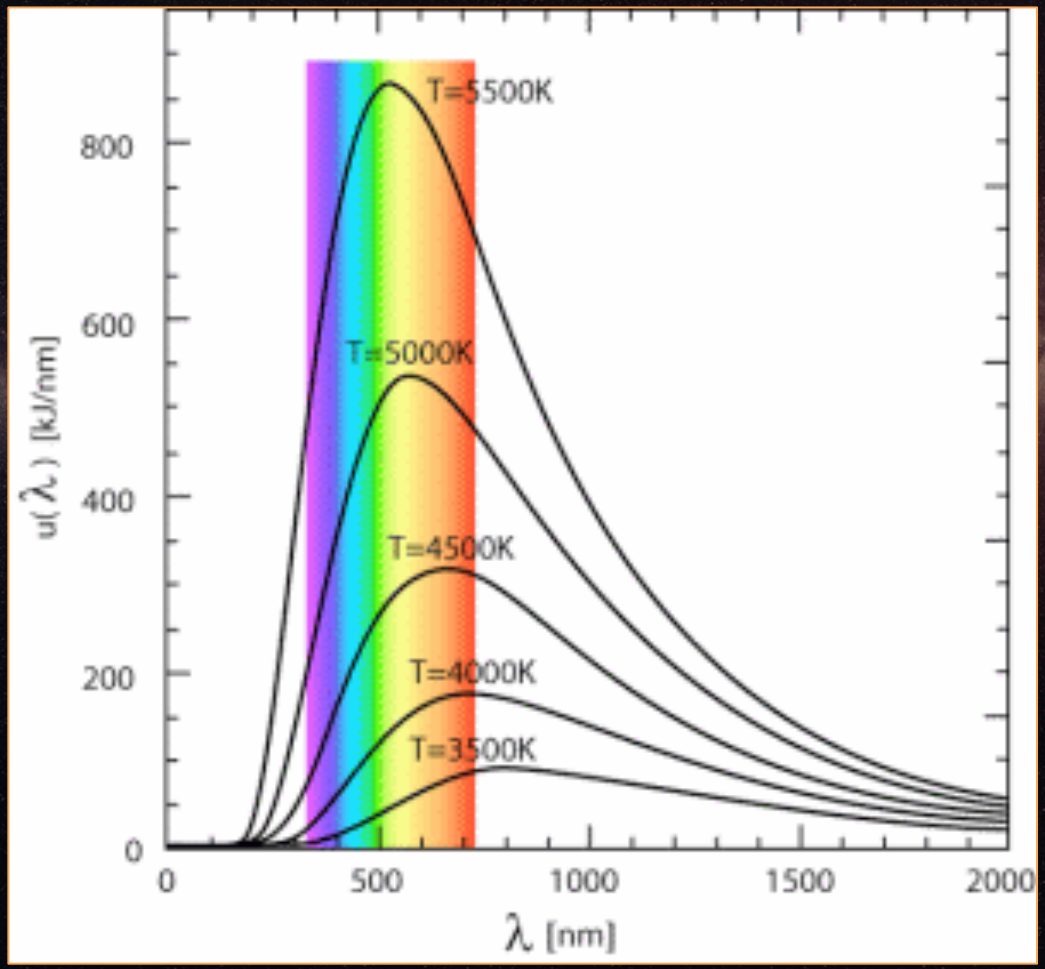
Finished product

Ingredients + recipe

- *Size*
- *Temperature*
- *Composition*

The Wien's law

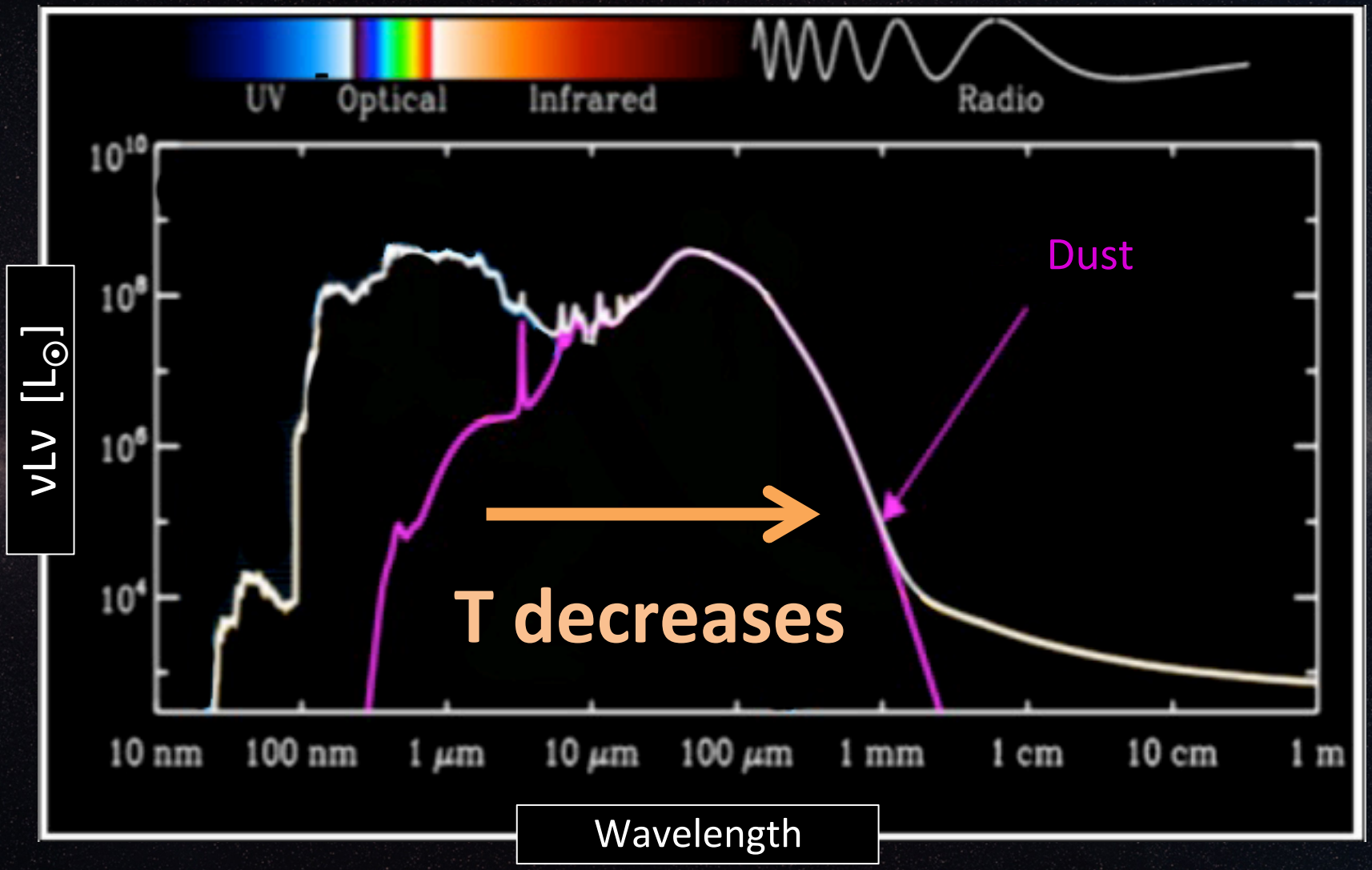
$$\lambda_{peak} T = 2.898 \cdot 10^{-3} m \cdot K$$



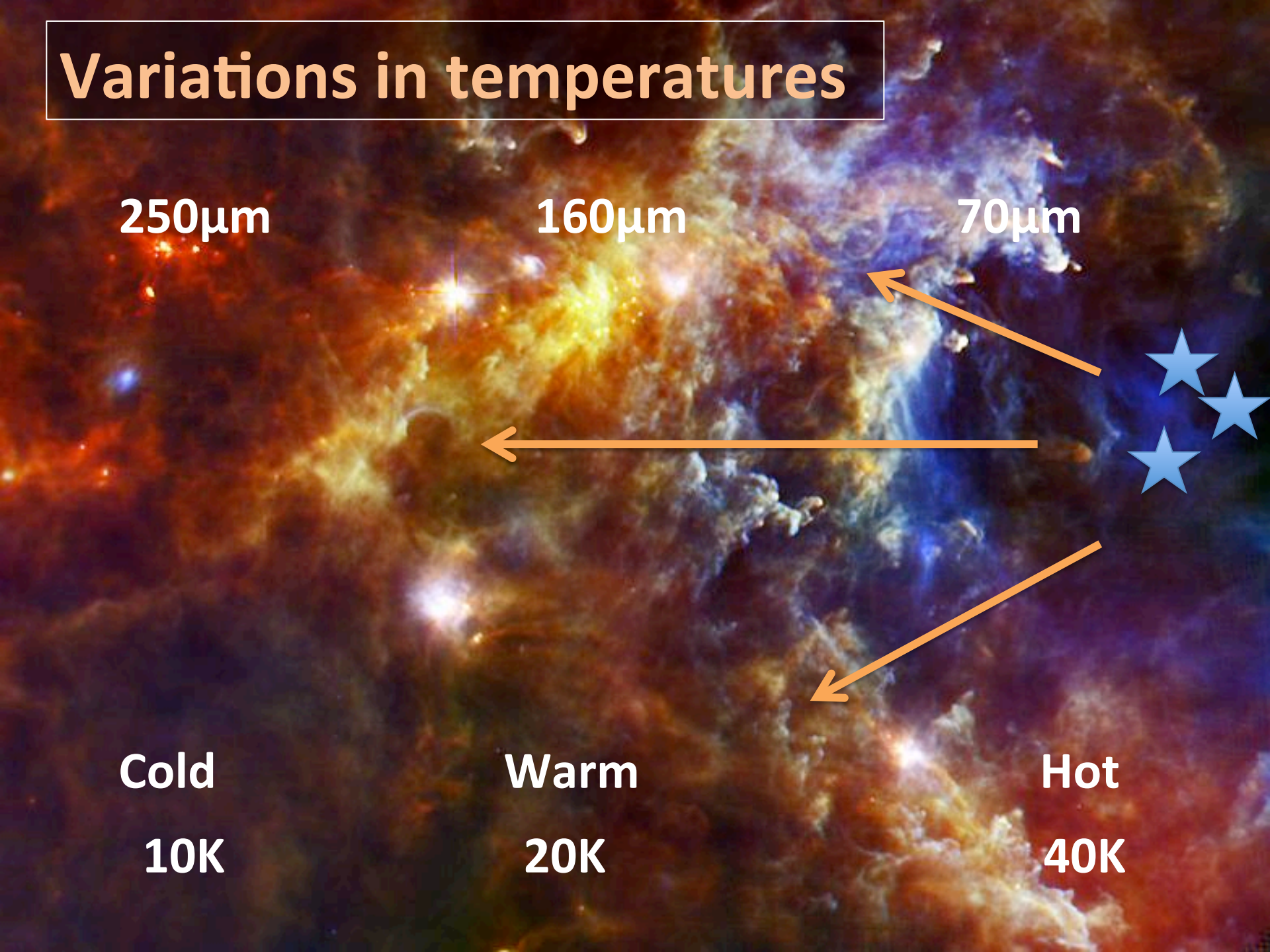
The peak wavelength

gives

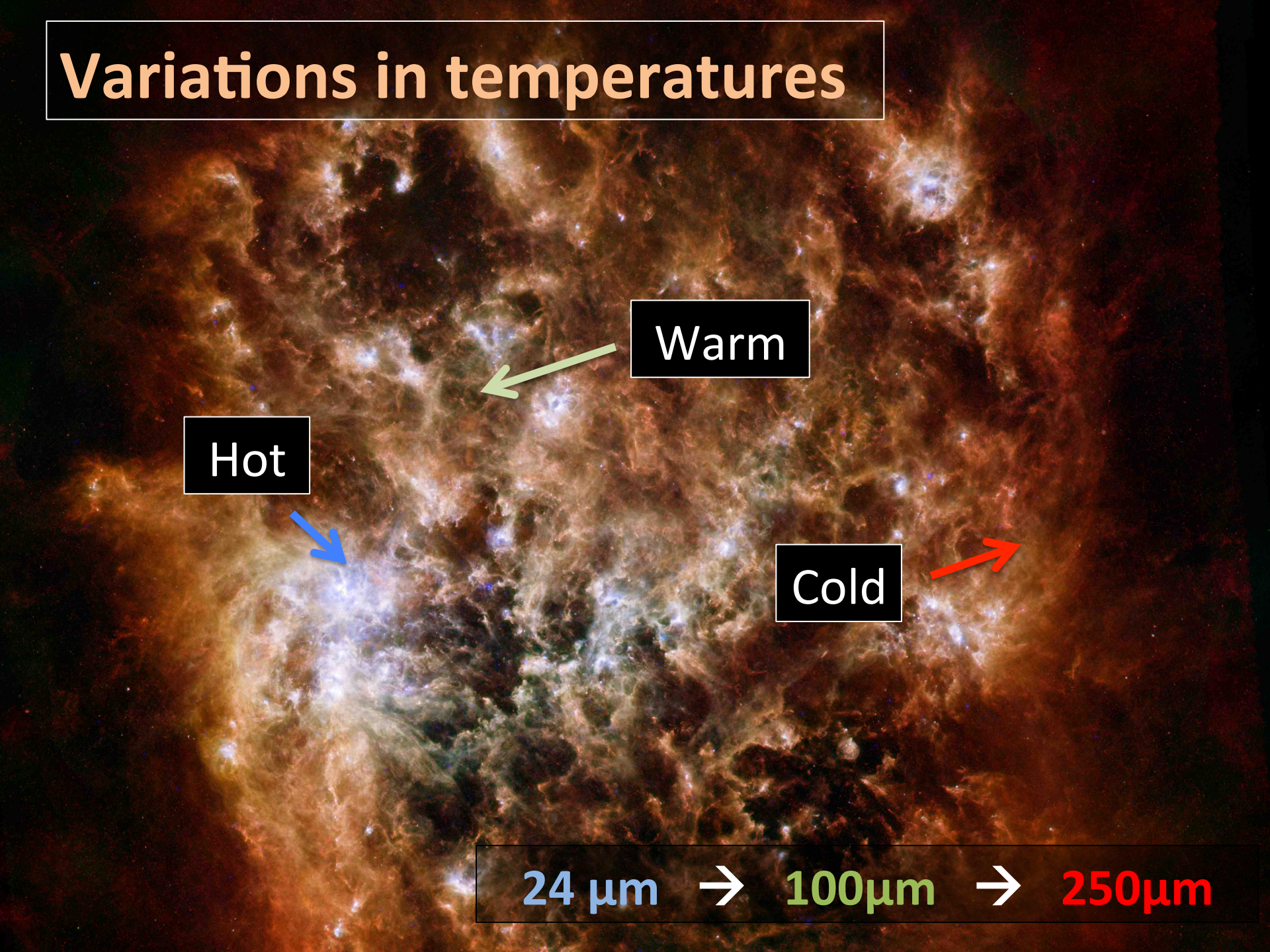
a measure of temperature


UV
Optical
Infrared
Radio
10^{10}
10^{8}
10^{6}
10^{4}
νLν [L⊙]
Dust
T decreases
10 nm
100 nm
1 μm
10 μm
100 μm
1 mm
1 cm
10 cm
1 m
Wavelength

Variations in temperatures



Variations in temperatures

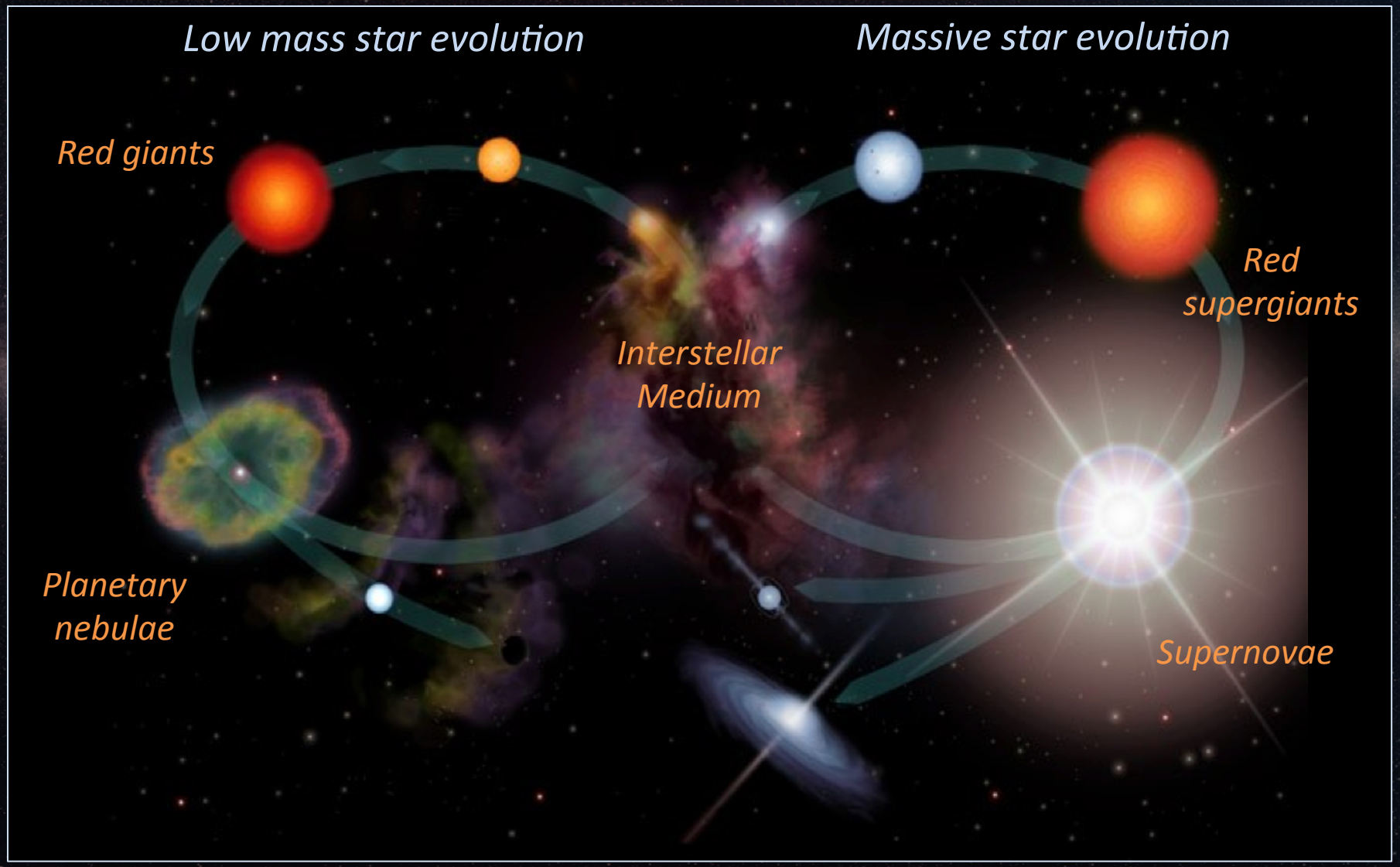


Finished product

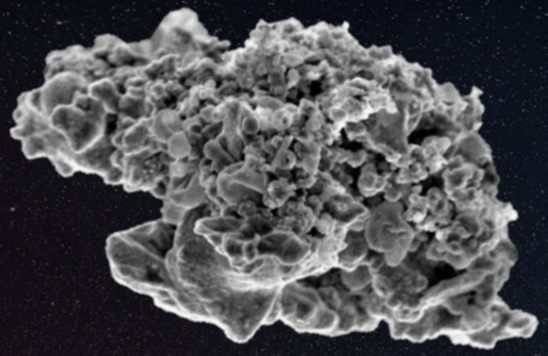
Ingredients + recipe

- ***Size***
- ***Temperature***
- ***Composition***

The cycle of life of dust



The dust composition



Products synthesized in stars:

- Carbon
- Oxygen
- Nitrogen & Sulfur
- Mg, Fe, Si, Ni, Cr & Mn
- Rarer elements

→ are the direct components of our dust grains

Carbon grains

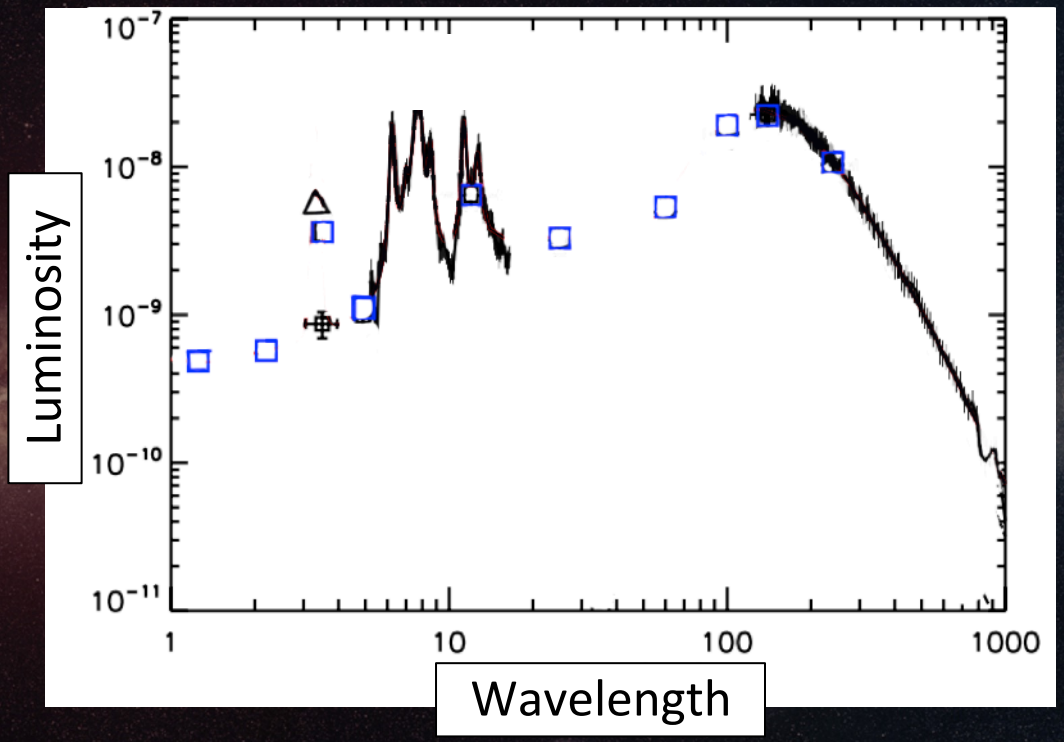
Silicates

Grains are then transformed …

What now?

What now?

Cake

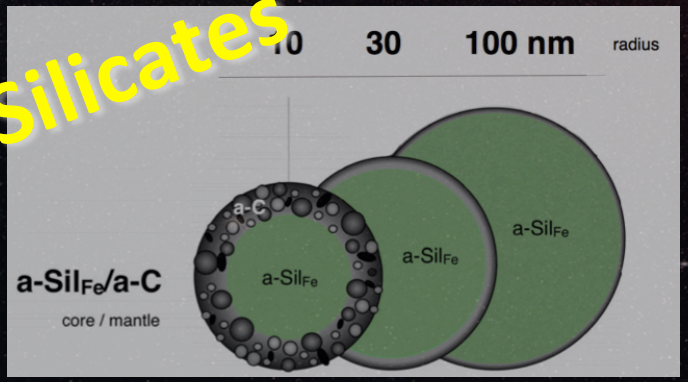


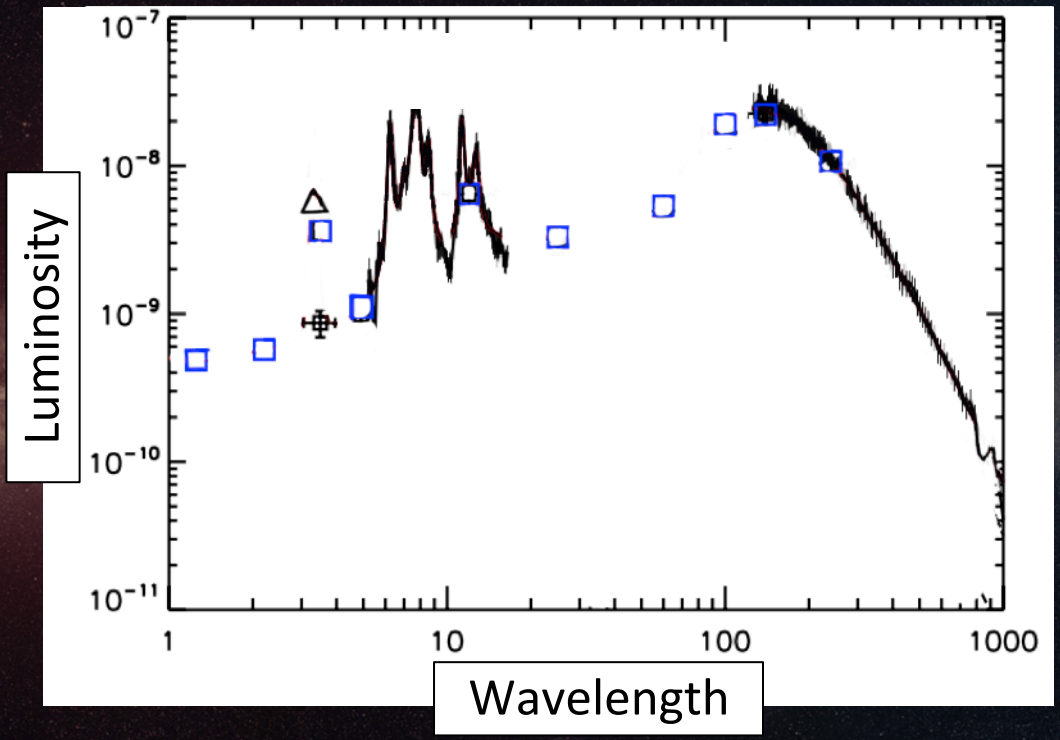
What now?

Ingredients

Carbon grains

Silicates

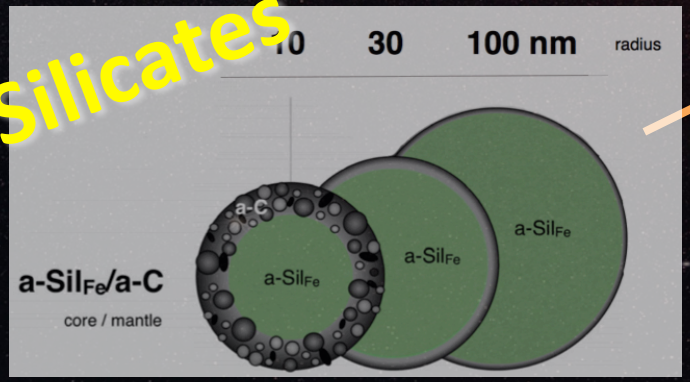


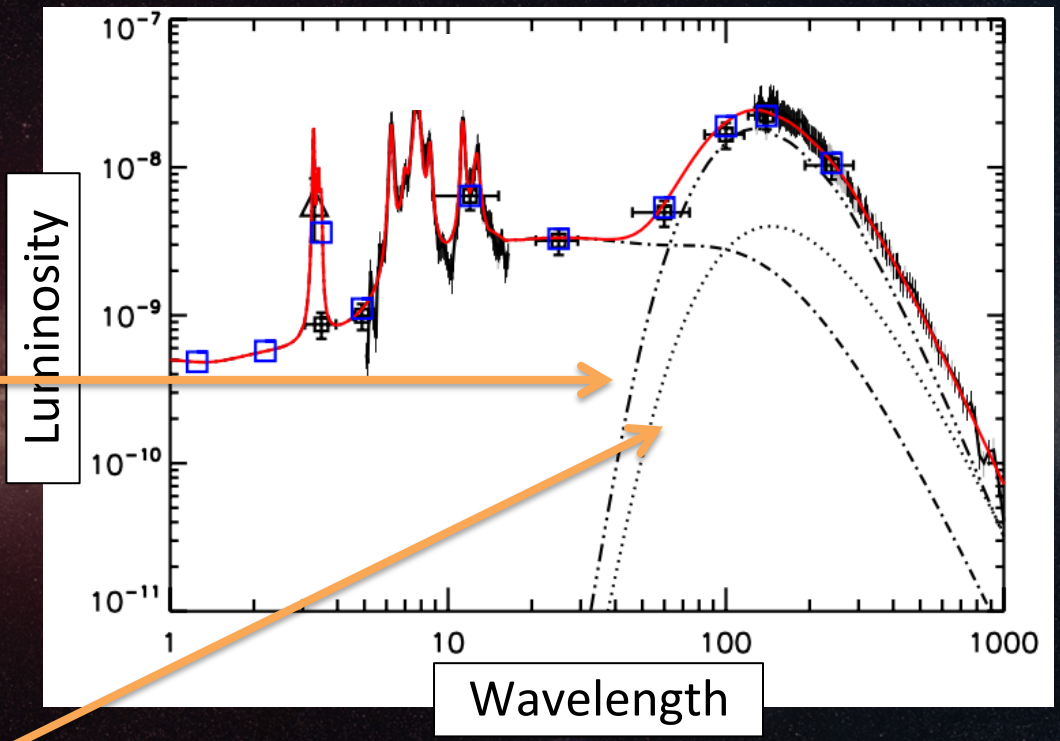


A little bit of this, a little bit of that …

Carbon grains

Silicates





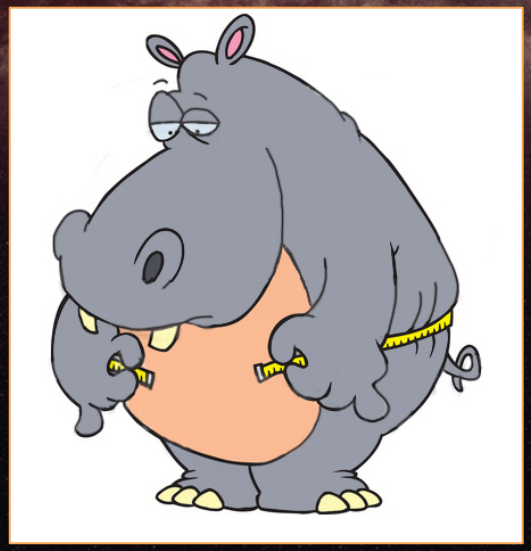
→ Recipe

Take away messages

→ Major progress due to Infrared astronomy

→ The emission of a dust grain depends on:

Its composition



Its size

Its temperature

Other telescopes

- From 1989 to now
- Full mapping missions

COBE / WMAP / Planck