

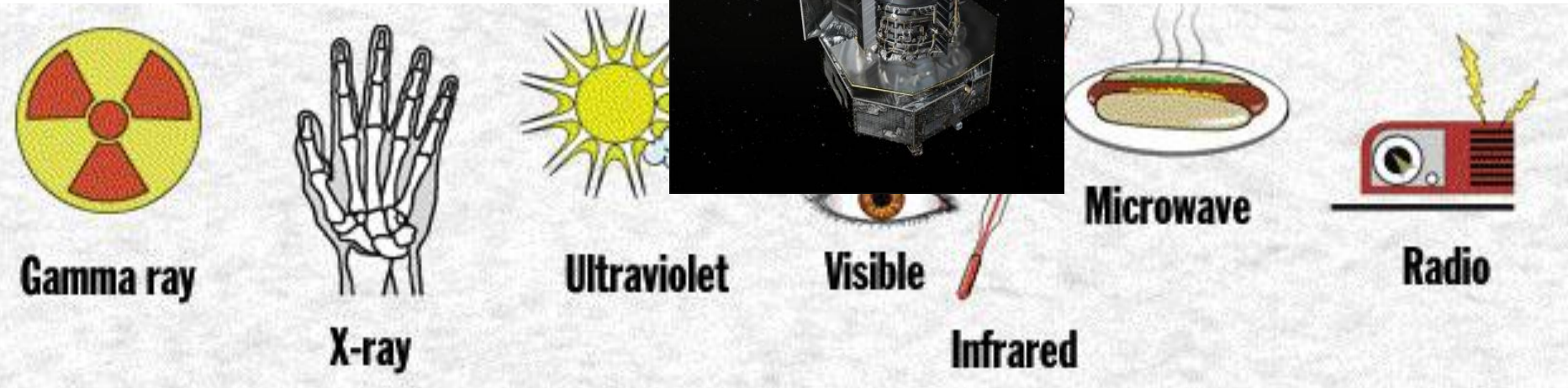
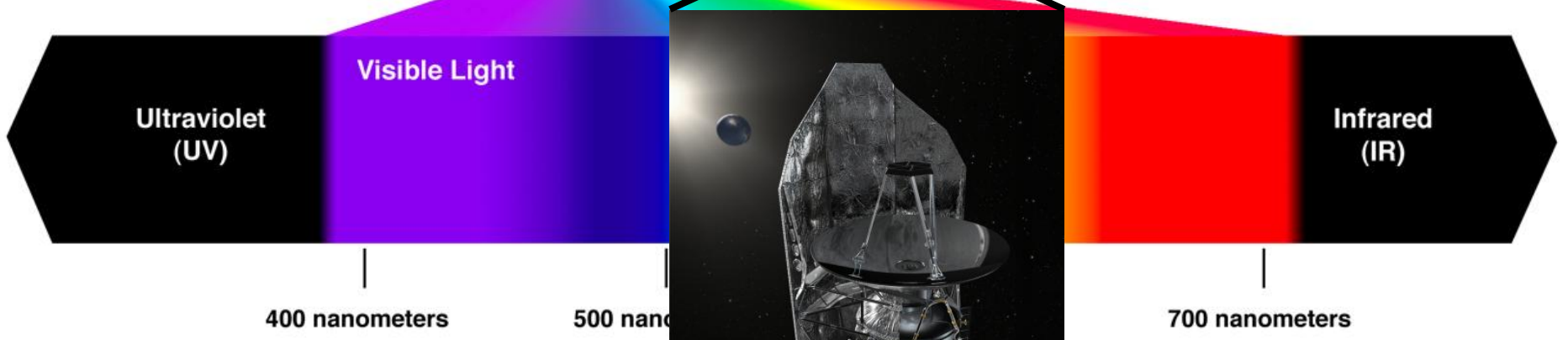
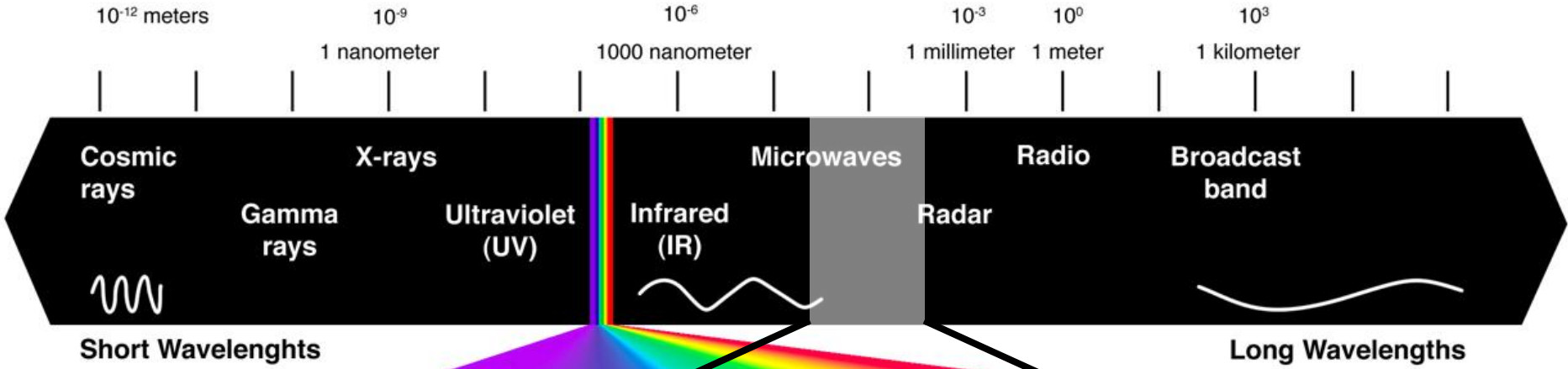
# SCIENCE WITH HERSCHEL

Ruud Visser

Postdoc  
Sterrewacht Leiden

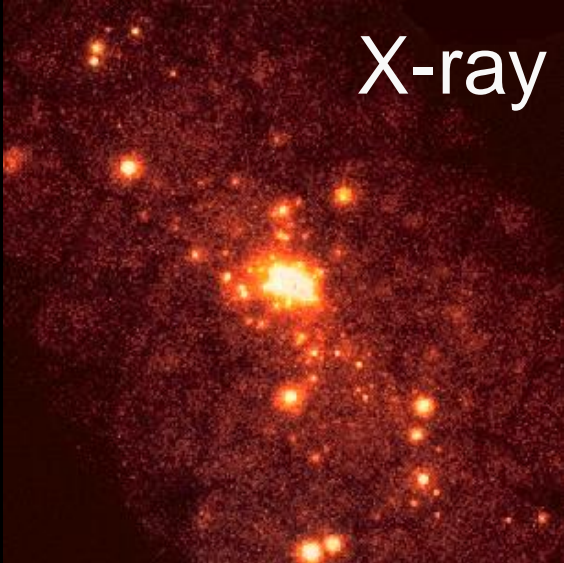
October 28, 2010





# ASTRONOMICAL OBSERVATIONS

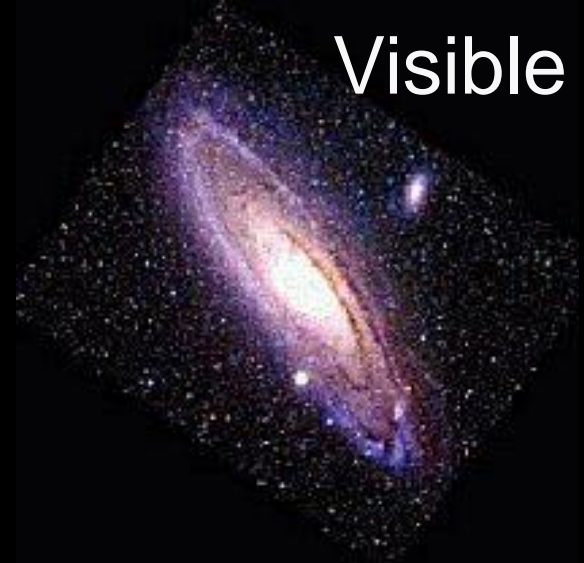
X-ray



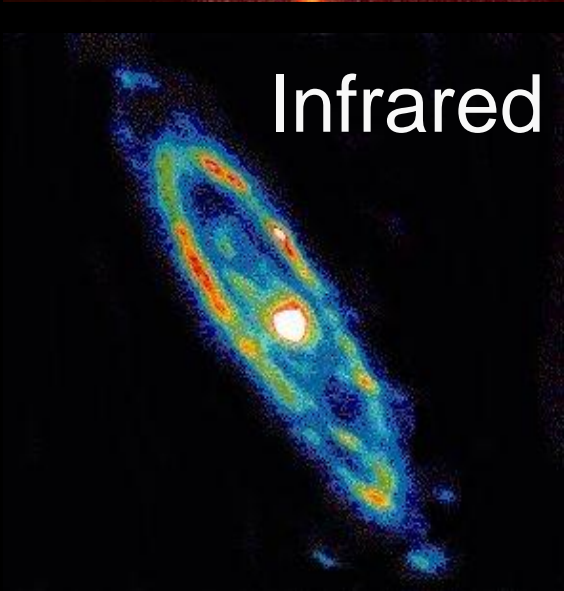
Ultraviolet



Visible



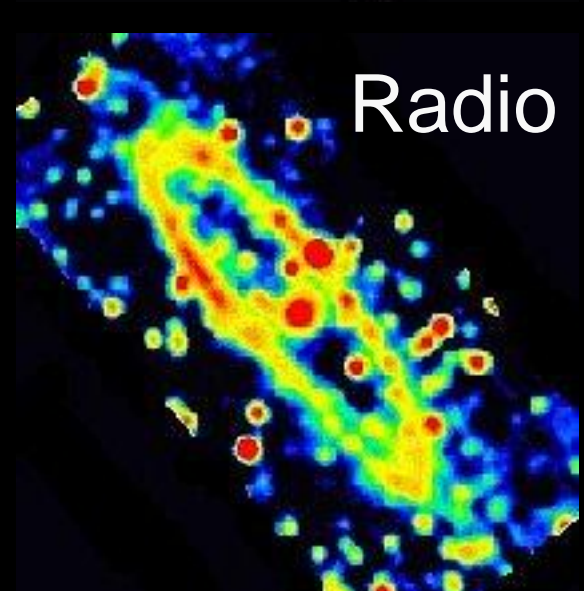
Infrared



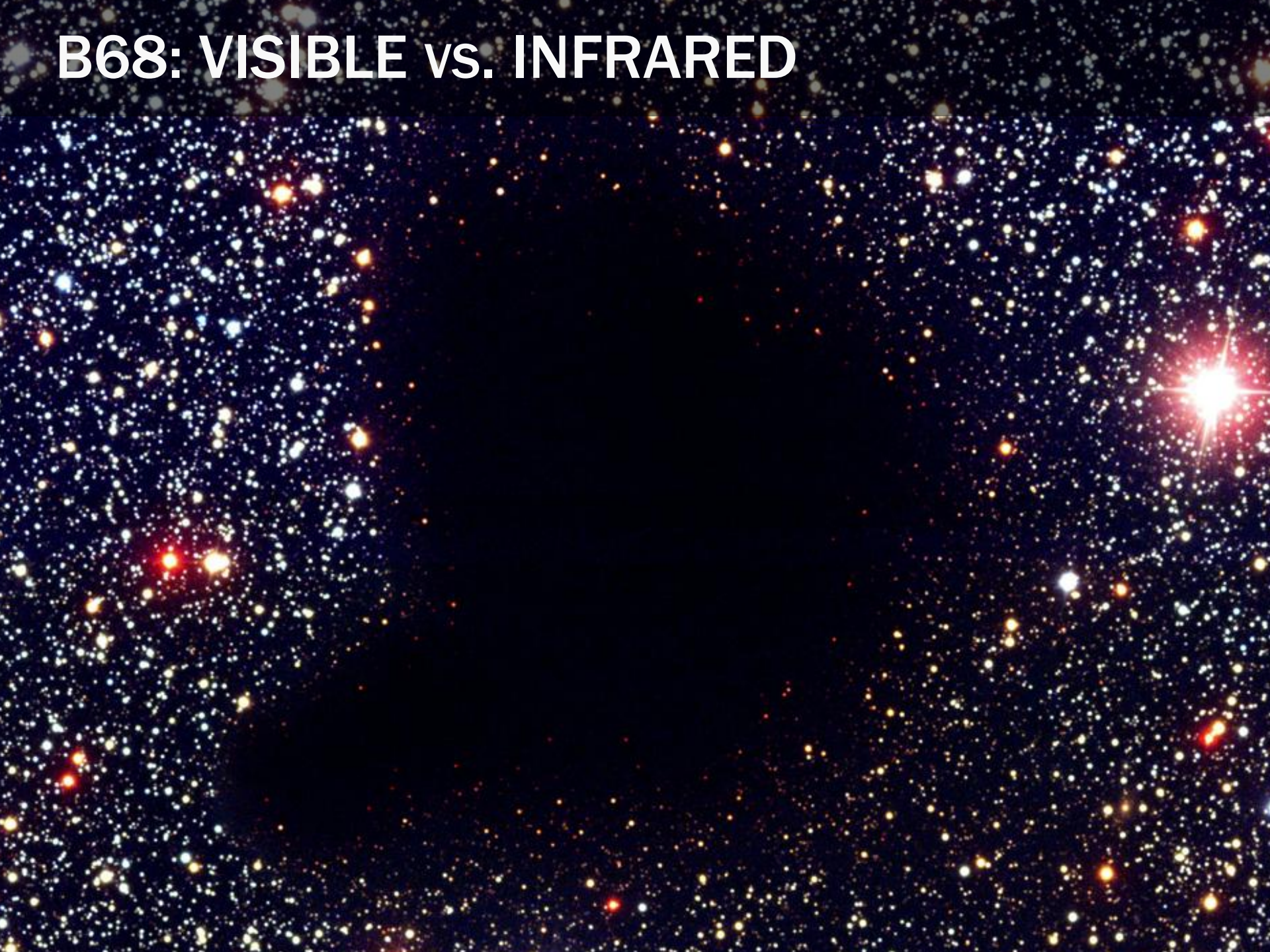
Microwave



Radio



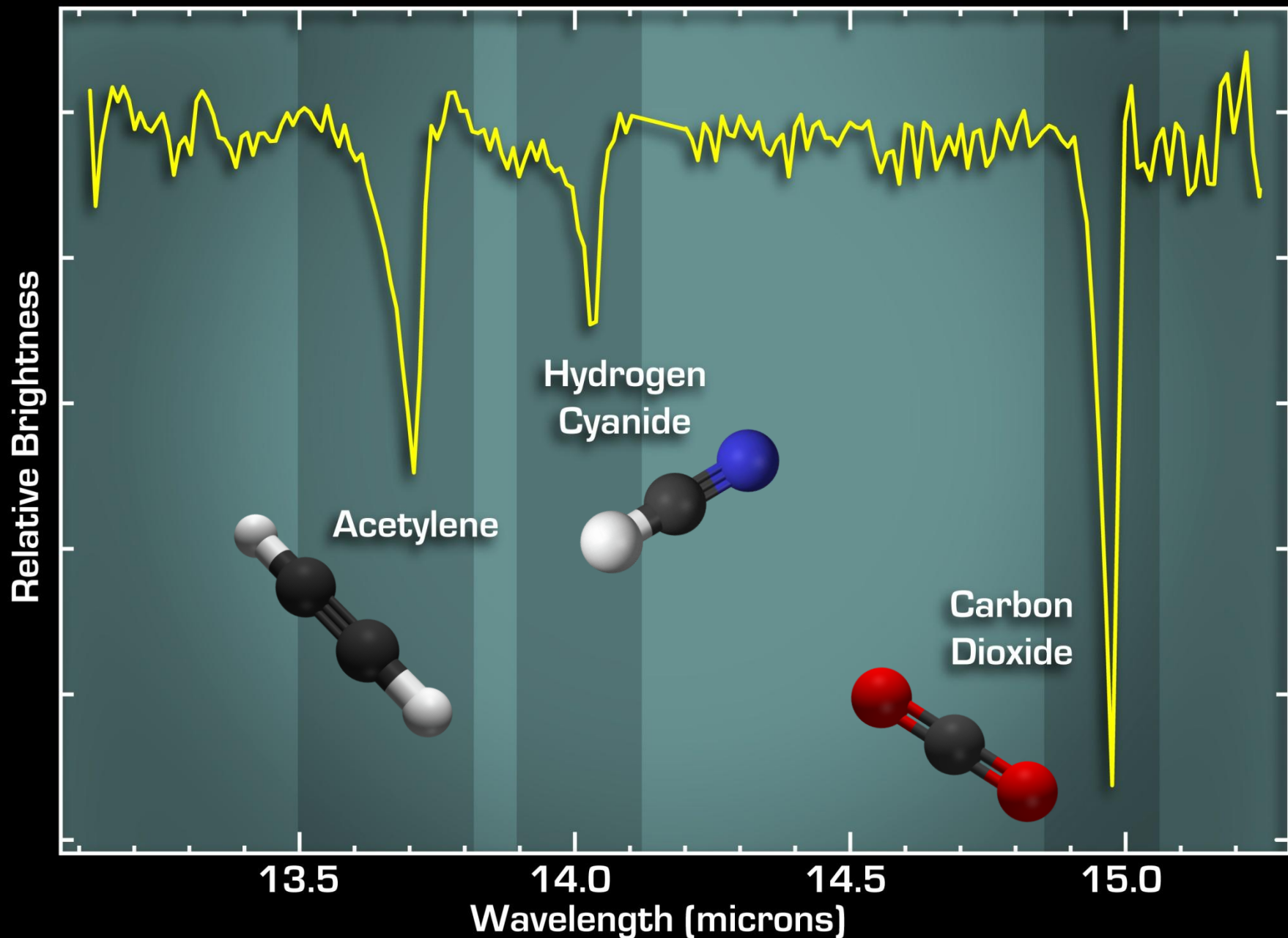
# B68: VISIBLE vs. INFRARED



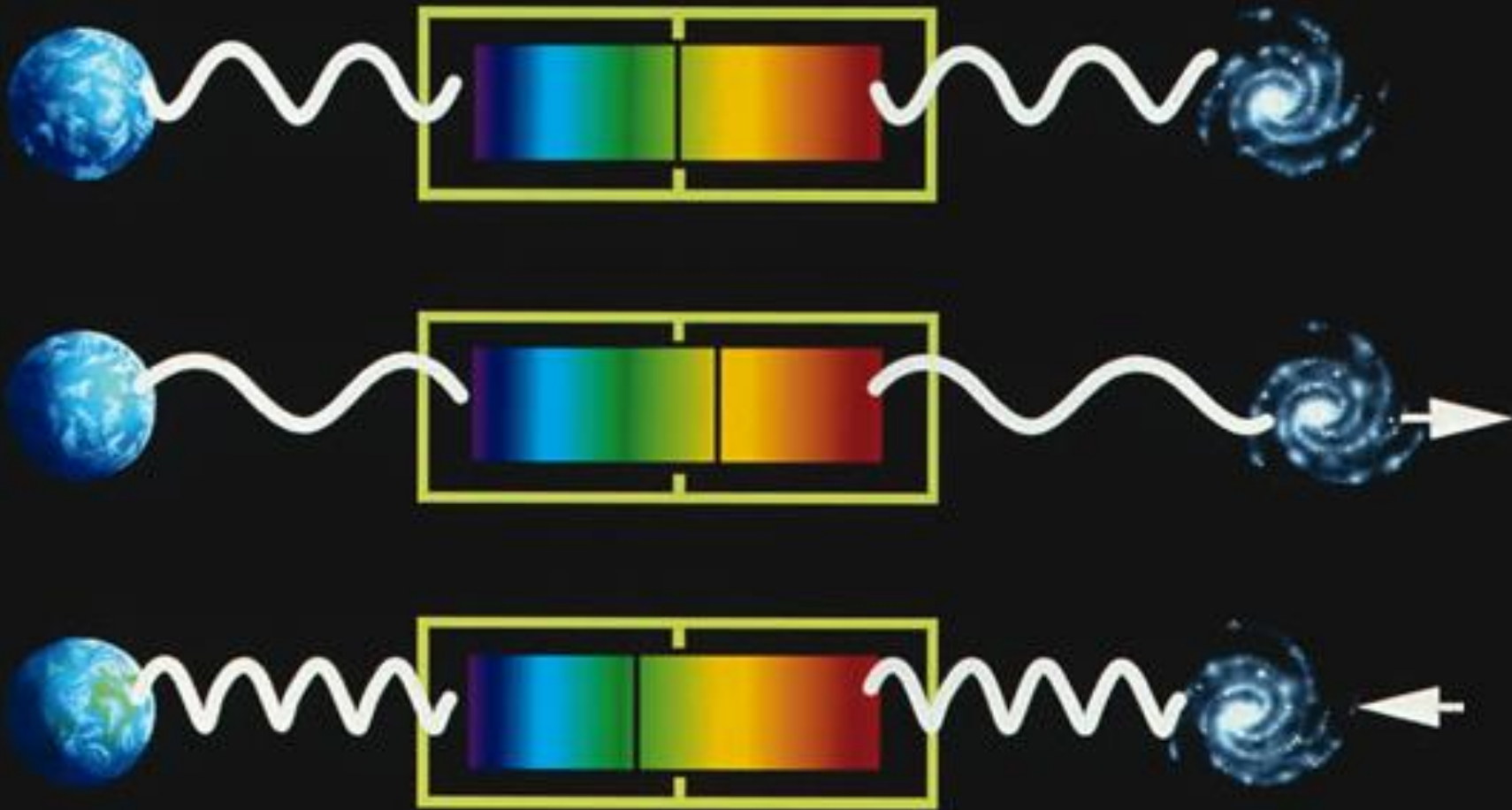
# HERBIG-HARO 46/47



# MOLECULAR FINGER PRINTS



# DOPPLER SHIFT

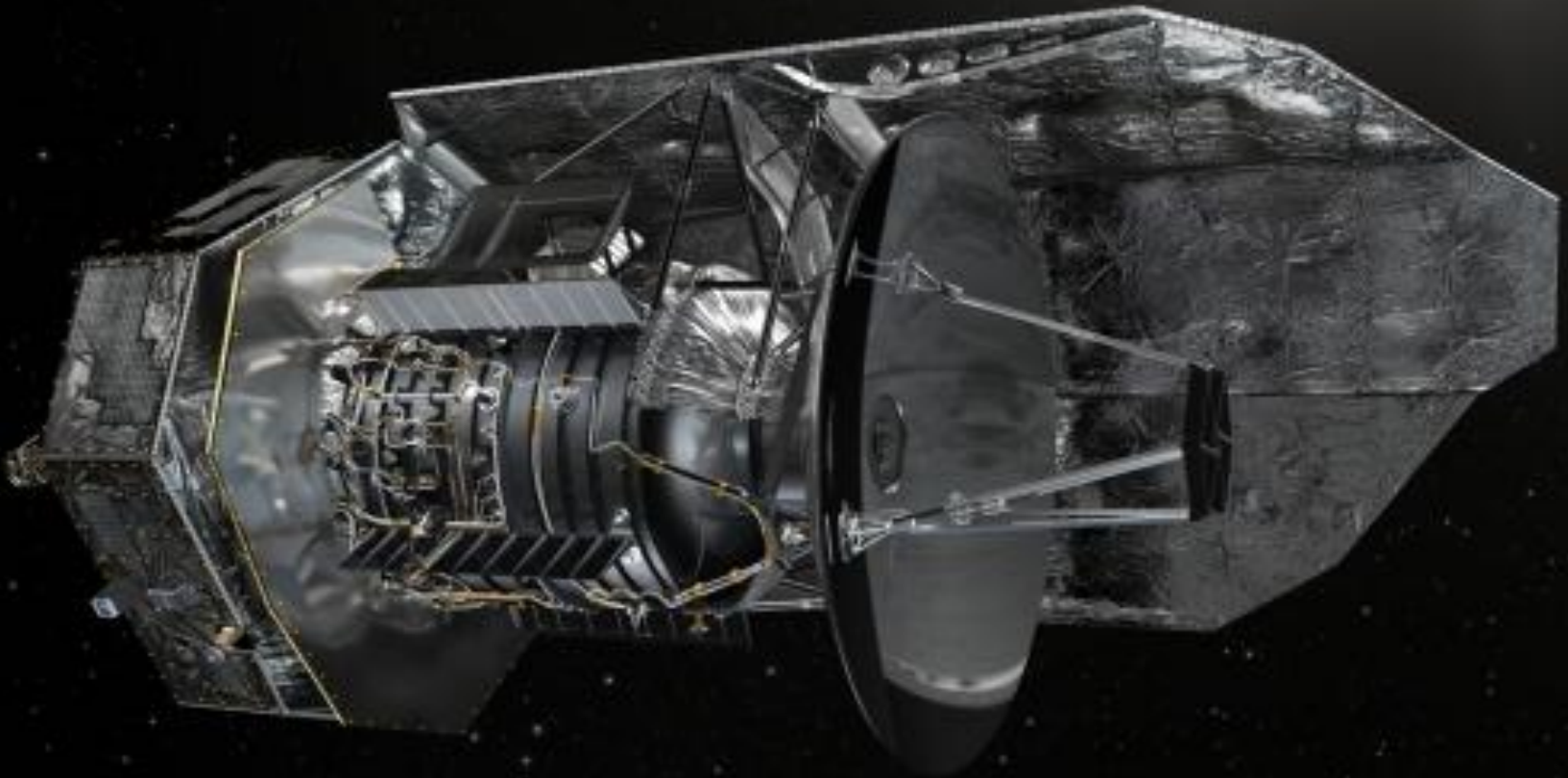


Spectral lines change in wavelength:  
Longer wavelength (redshift) if object moves away from us  
Shorter wavelength (blueshift) if object moves towards us

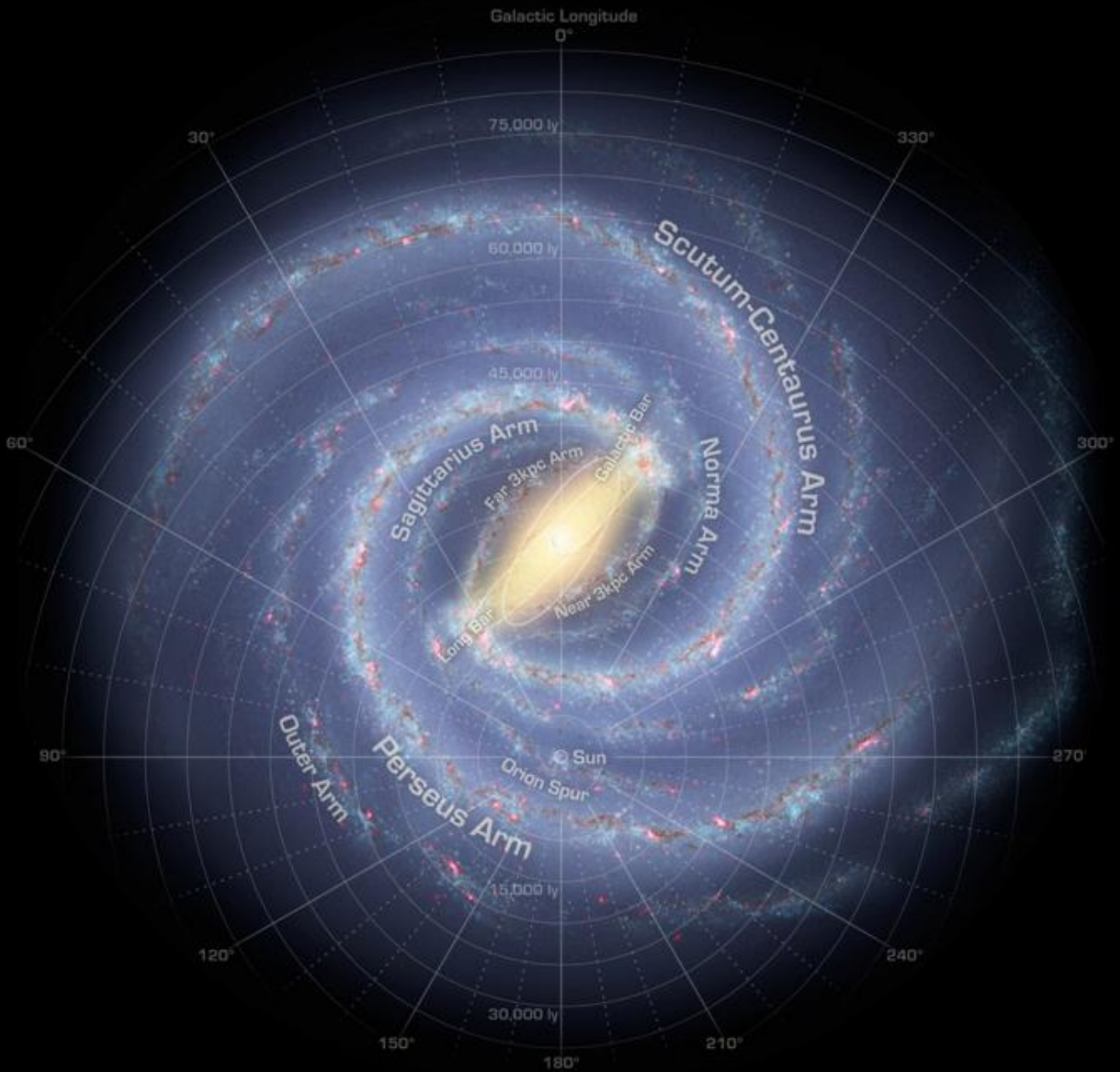
# HIFI's HIGH SPECTRAL RESOLUTION

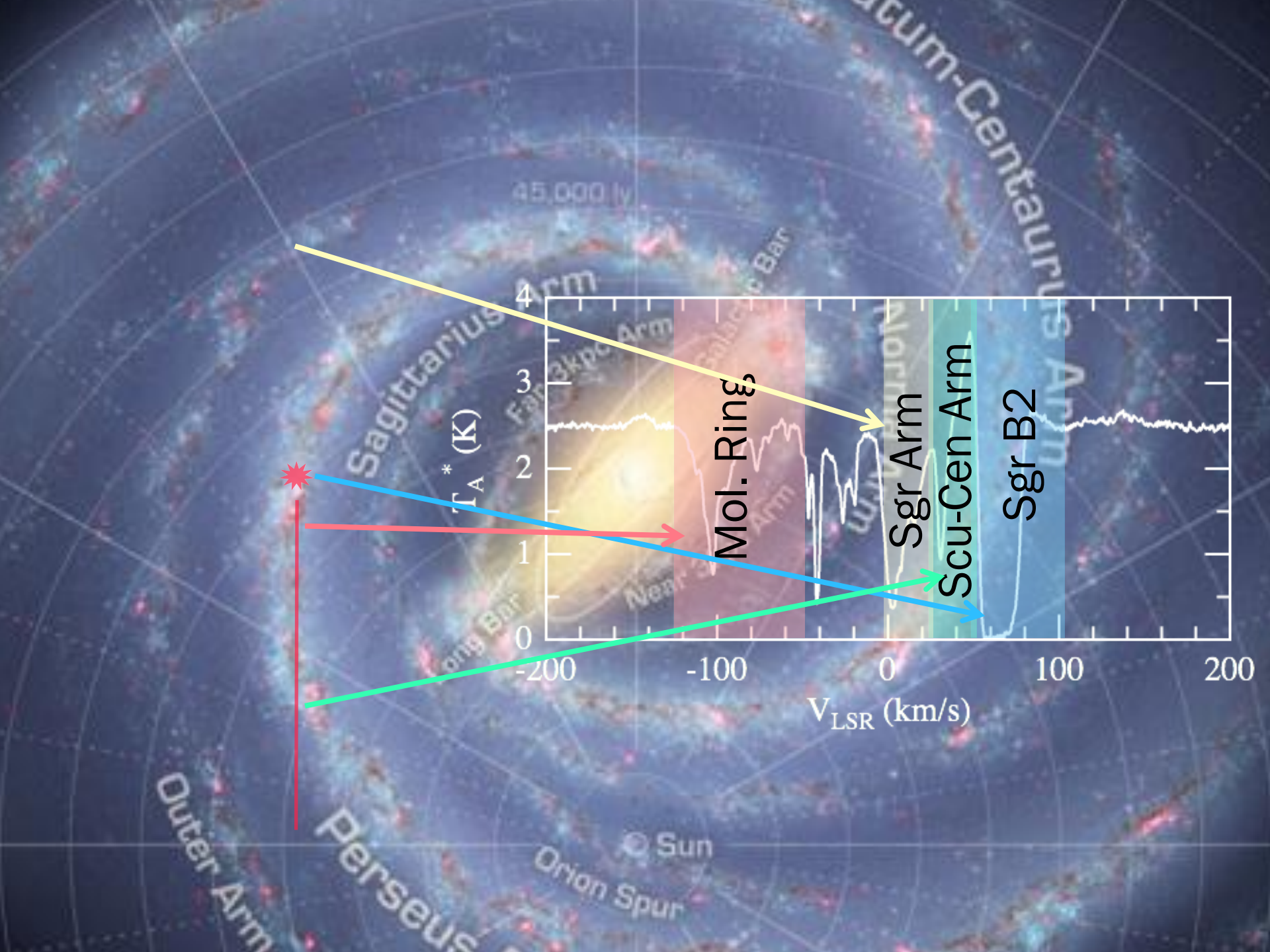
Wavelength shift = velocity

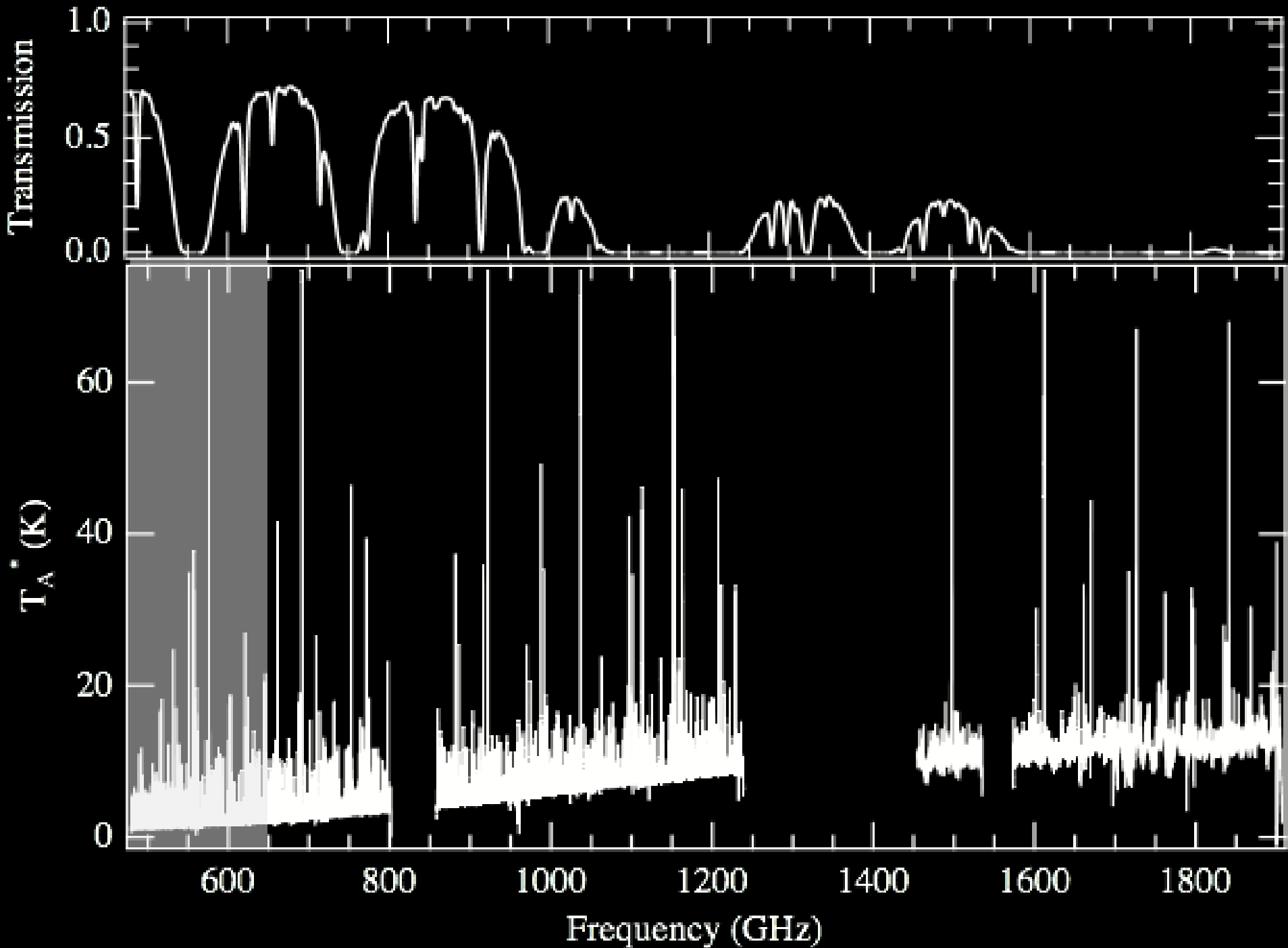
High spectral resolution =  
accurate velocity measurement

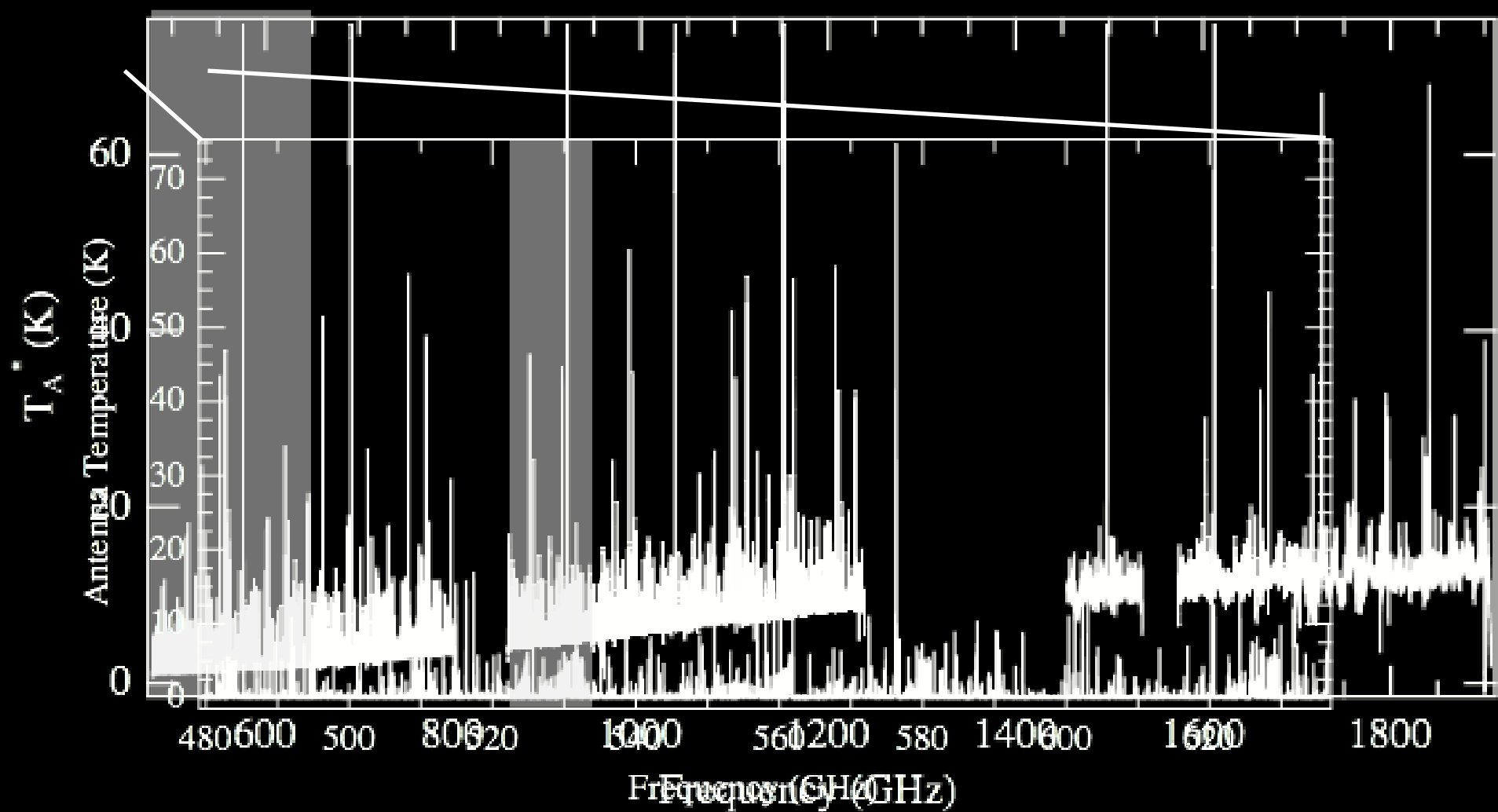


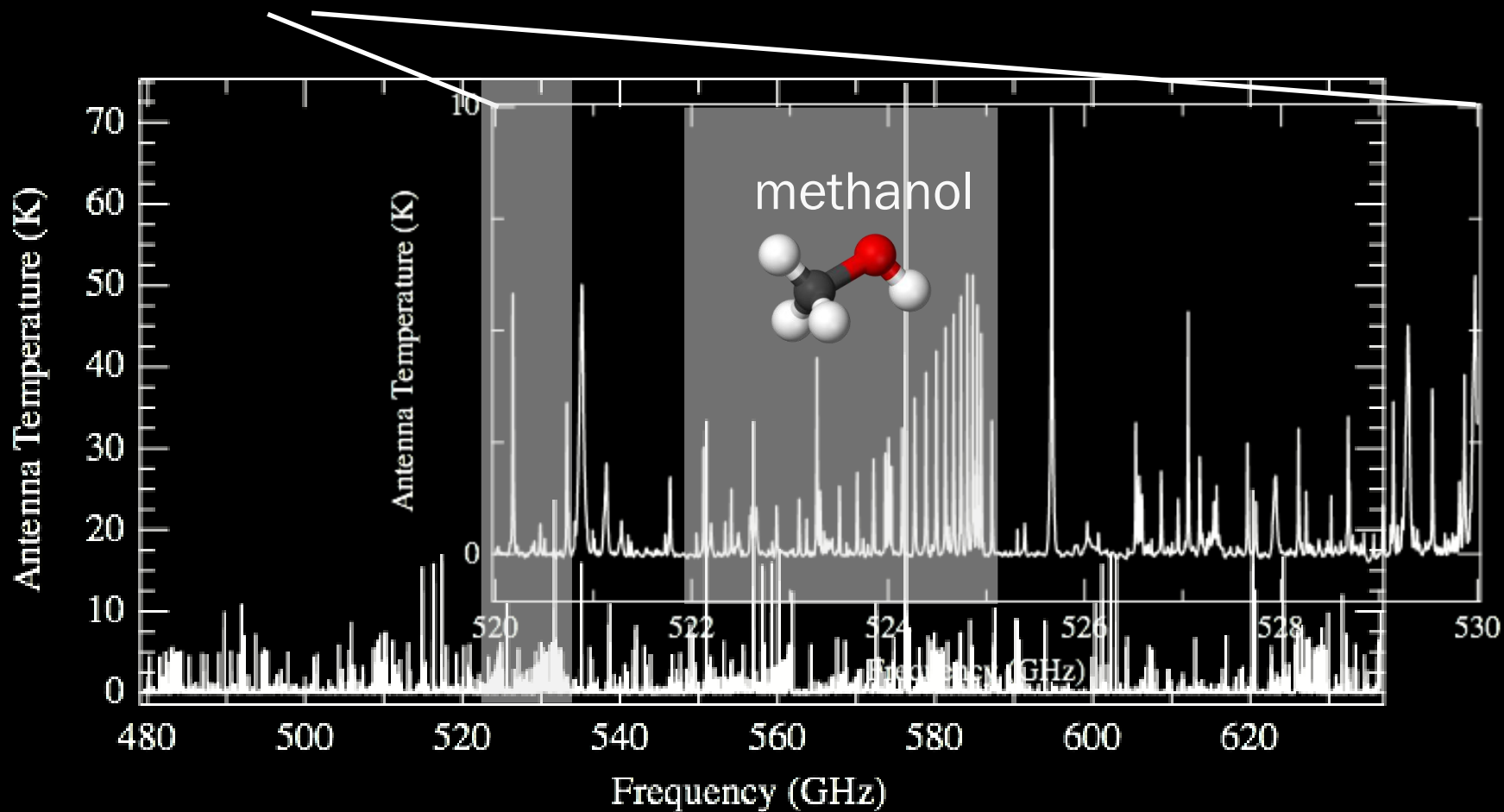






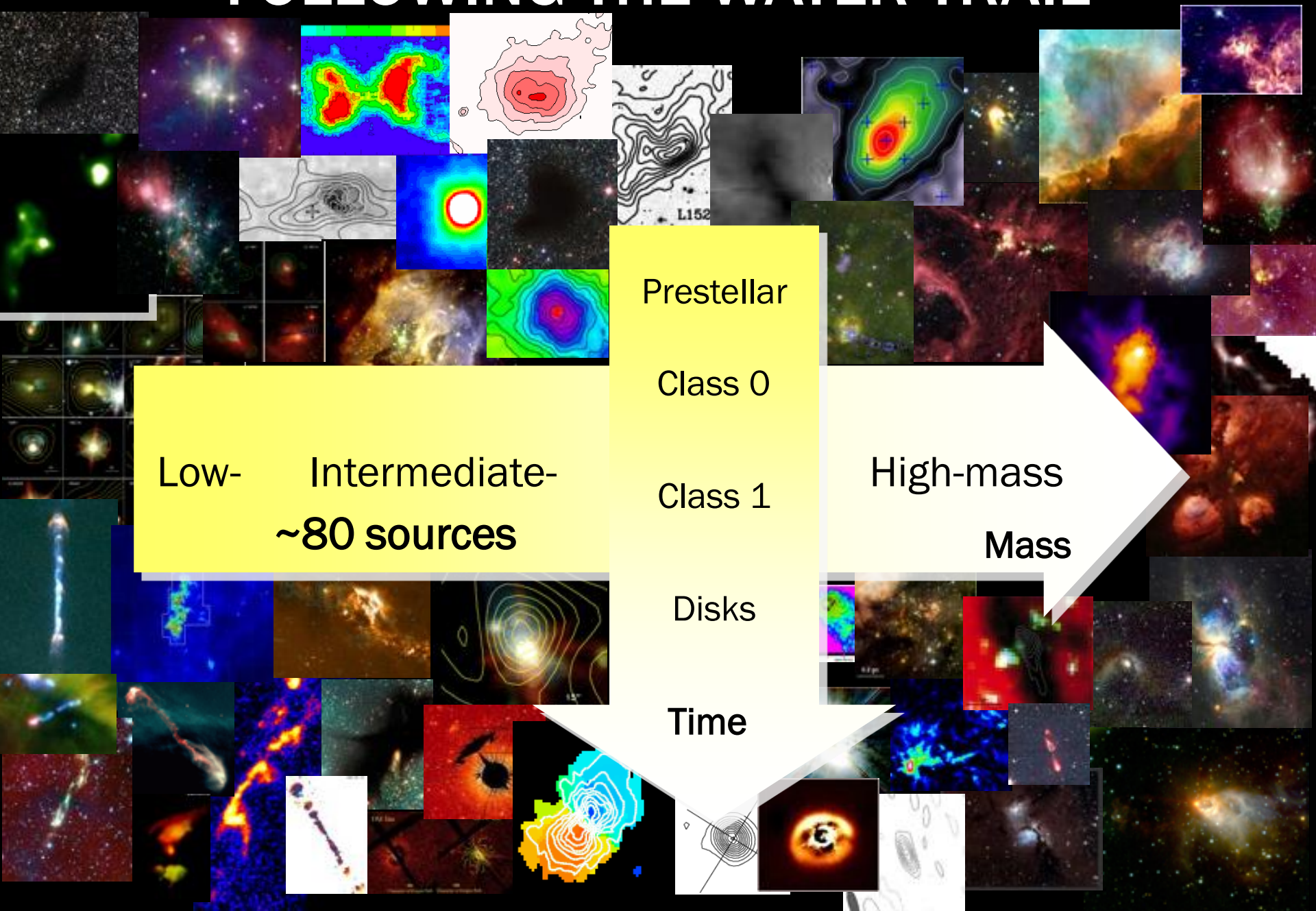






H<sub>2</sub>CHO HOCH<sub>2</sub>CHO C<sub>3</sub>H<sub>7</sub>CN c-C<sub>3</sub>H<sub>2</sub>O  
CH<sub>2</sub>CNH C<sub>8</sub>H CH<sub>3</sub>CONH<sub>2</sub> CH<sub>3</sub>NH<sub>2</sub>  
CH<sub>3</sub>COOH CH<sub>3</sub>NC C<sub>8</sub>H<sup>-</sup> HCOOCH<sub>3</sub>  
HC<sub>5</sub>N NH<sub>2</sub>CH<sub>2</sub>CN CH<sub>3</sub>C<sub>3</sub>N  
C<sub>2</sub>H<sub>4</sub> HC<sub>6</sub>H HOCH<sub>2</sub>CH<sub>2</sub>OH HC<sub>4</sub>H  
C<sub>2</sub>H<sub>3</sub>OH C<sub>2</sub>H<sub>5</sub>CN H<sub>2</sub>C<sub>6</sub> HCOOC<sub>2</sub>H<sub>5</sub>  
CH<sub>3</sub>CHCH<sub>2</sub> CH<sub>2</sub>CCHCN H<sub>2</sub>C<sub>4</sub>  
C<sub>2</sub>H<sub>5</sub>OH HC<sub>11</sub>N C<sub>6</sub>H<sup>-</sup> CH<sub>3</sub>OCH<sub>3</sub>  
NH<sub>2</sub>CHO C<sub>6</sub>H HC<sub>3</sub>NH<sup>+</sup> CH<sub>3</sub>CHO  
C<sub>7</sub>H CH<sub>3</sub>CN C<sub>5</sub>H  
HC<sub>4</sub>N CH<sub>3</sub>C<sub>6</sub>H CH<sub>3</sub>C<sub>4</sub>H HC<sub>7</sub>N C<sub>5</sub>N  
CH<sub>3</sub>OH C<sub>2</sub>H<sub>3</sub>CHO CH<sub>3</sub>SH  
CH<sub>3</sub>C<sub>5</sub>N CH<sub>3</sub>C<sub>2</sub>H C<sub>6</sub>H<sub>6</sub>  
C<sub>2</sub>H<sub>5</sub>CHO c-CH<sub>2</sub>OCH<sub>2</sub> HC<sub>9</sub>N C<sub>2</sub>H<sub>3</sub>CN

# FOLLOWING THE WATER TRAIL



Low- Intermediate-  
~80 sources

Prestellar  
Class 0  
Class 1  
Disks  
Time

High-mass  
Mass

# WATER WITH HERSCHEL

What?

- ✗ Water in Star-Forming Regions with Herschel
- ✗ Large international team (~80 people) led by Prof. Ewine van Dishoeck from Leiden
- ✗ 425 hours of HIFI and PACS
- ✗ Goal: use water to trace physics and chemistry



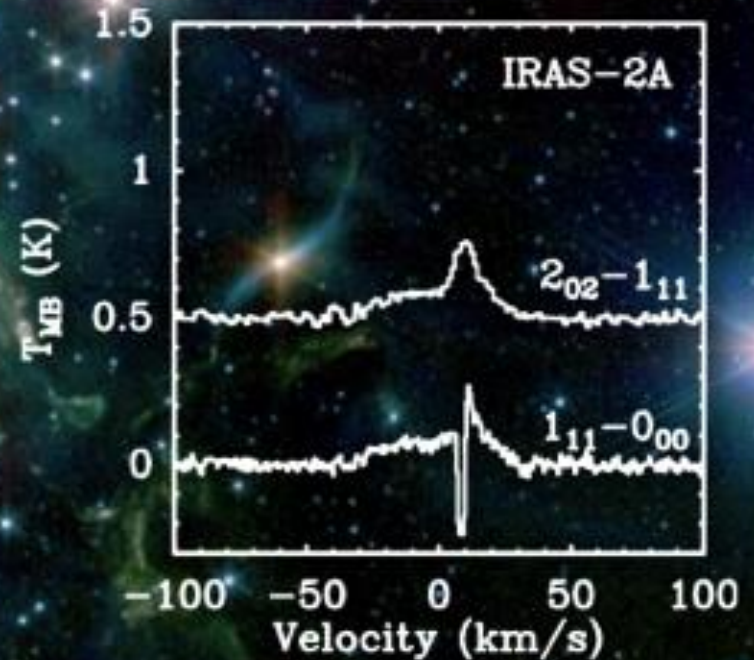
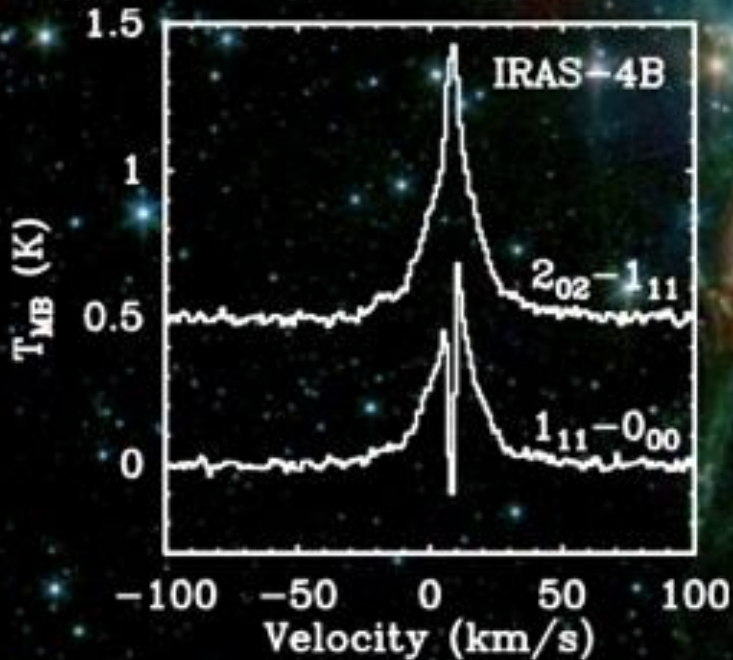
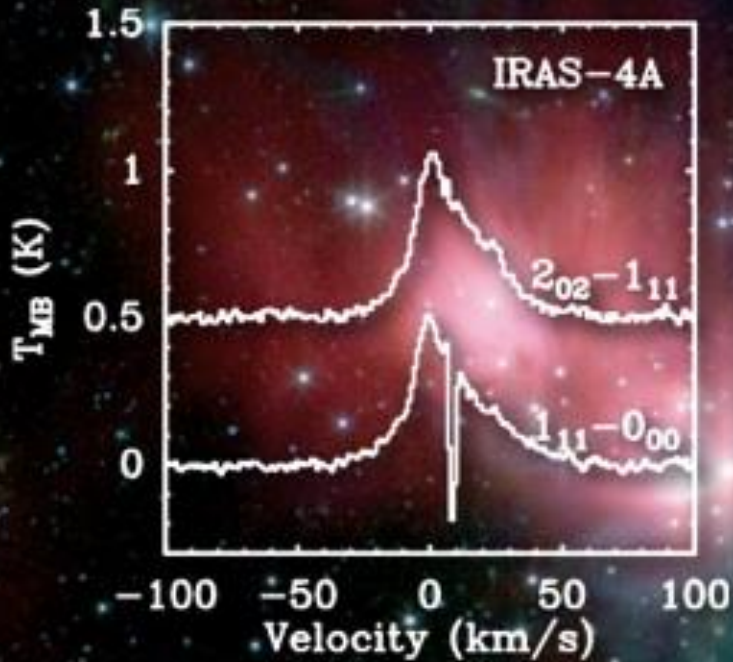
Why?

- ✗ Dynamical probe: see material at different velocities
- ✗ Main reservoir of oxygen
- ✗ Important for life on Earth

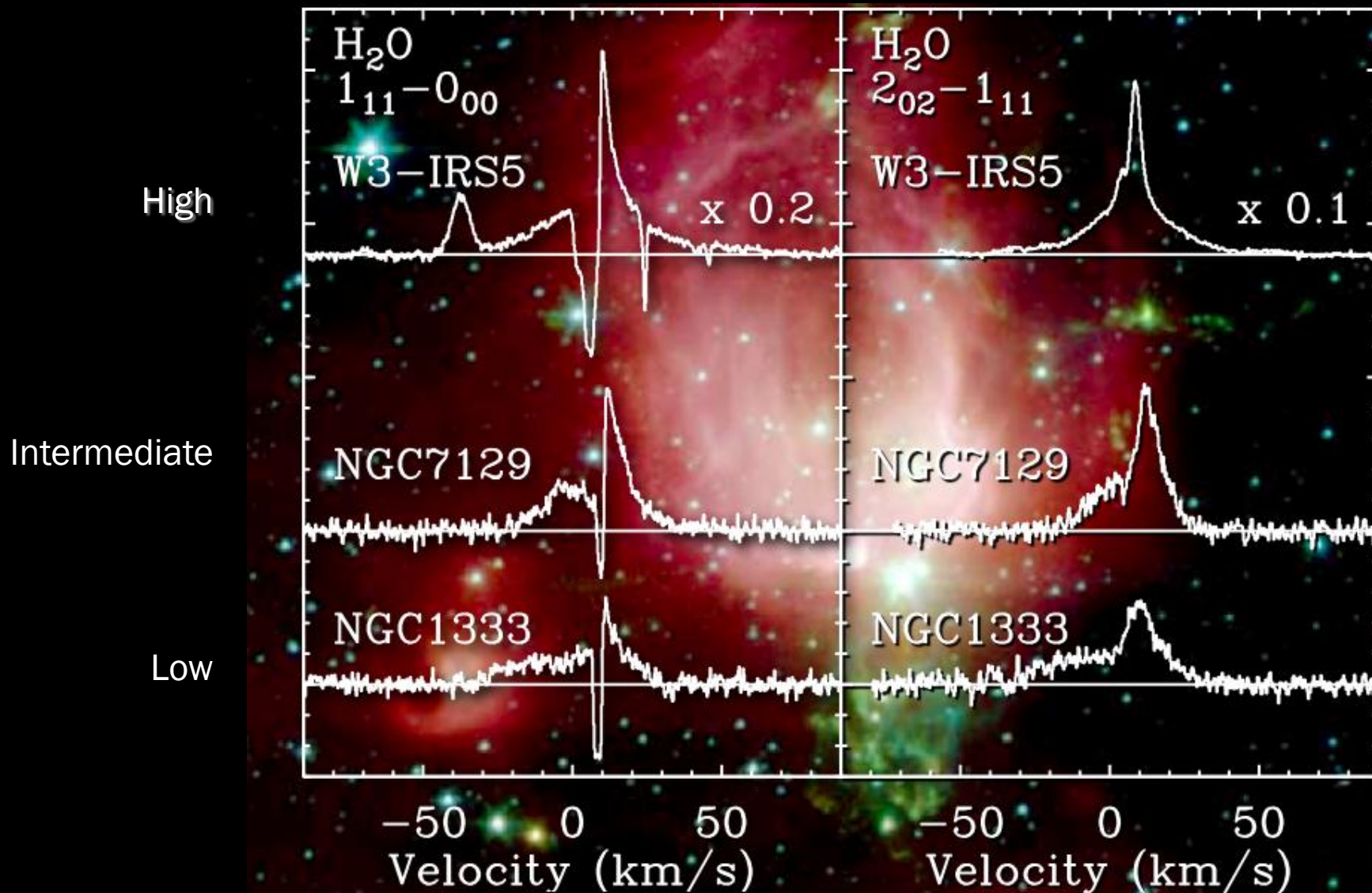


# Water in Perseus (nearby star-forming region)

- ✗ Line intensity:  
amount of water
- ✗ Line shape:  
temperature and velocity

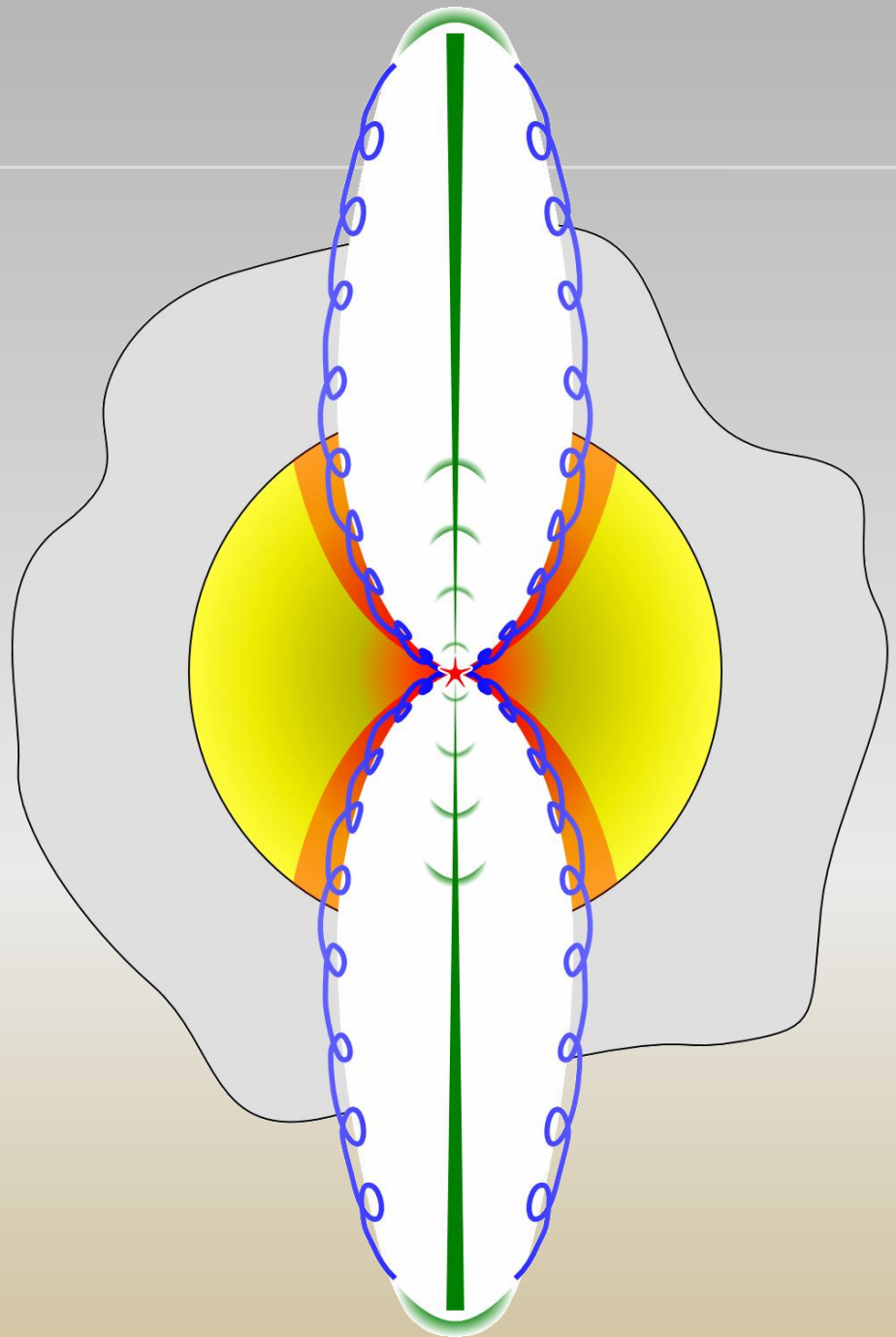


# FROM LOW TO HIGH MASS

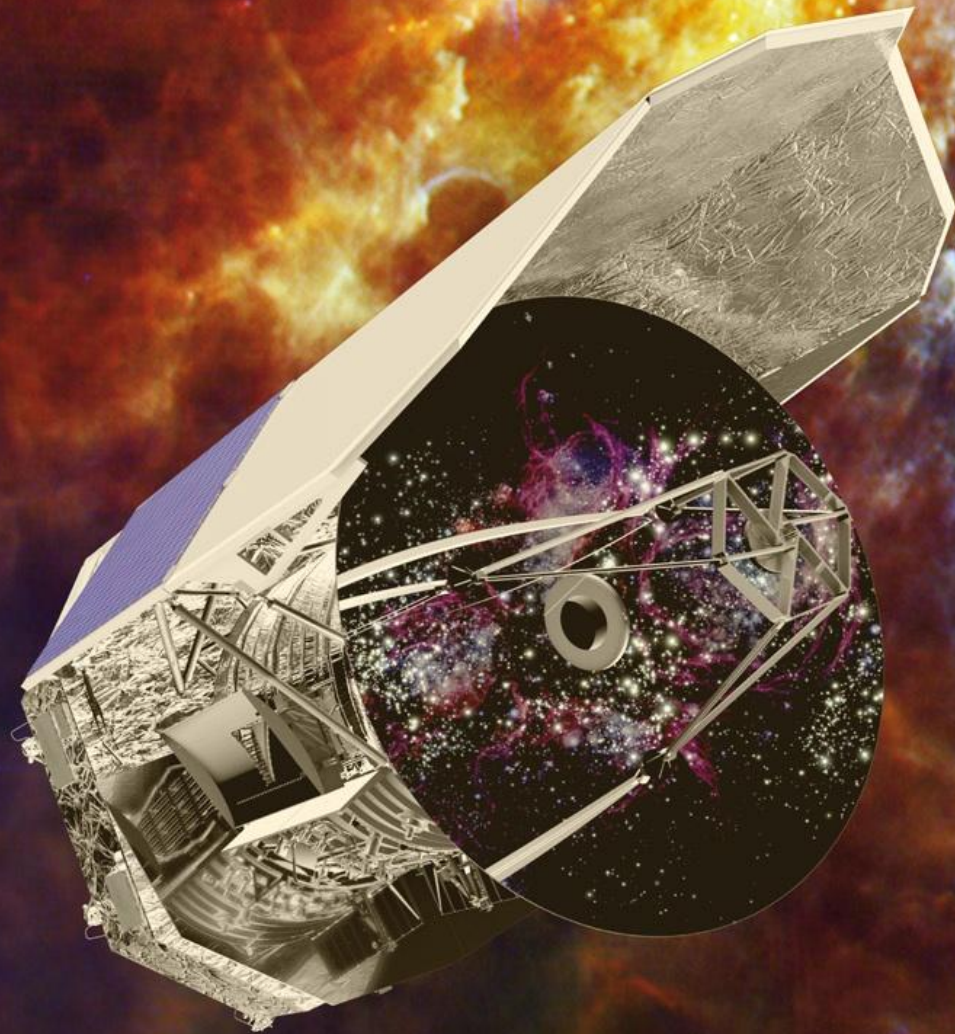


# COMPUTER MODEL

- ✘ Various components:
  - + Remnant cloud core
  - + Jets and outflows
  - + UV radiation
  - + Shocks
- ✘ Simulate emission from each component
- ✘ Working well for CO, not yet for water



# CONCLUSIONS



- ✘ Herschel and HIFI are great instruments
- ✘ Science highlights:
  - + Very rich chemical soup
  - + Different velocity components
  - + Disentangle formation of new stars