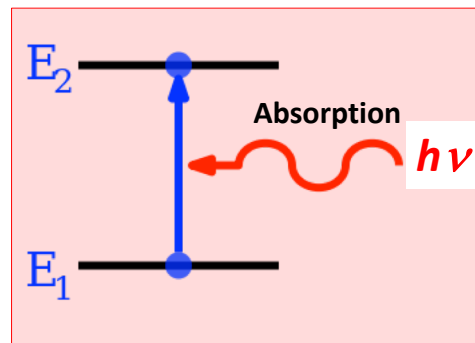
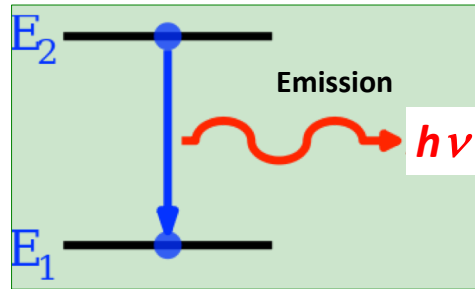
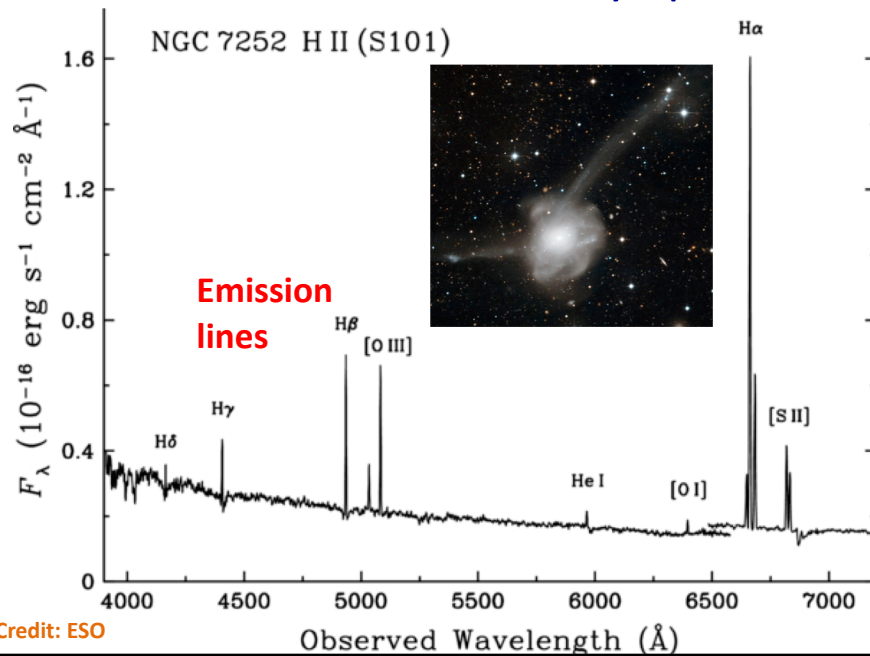


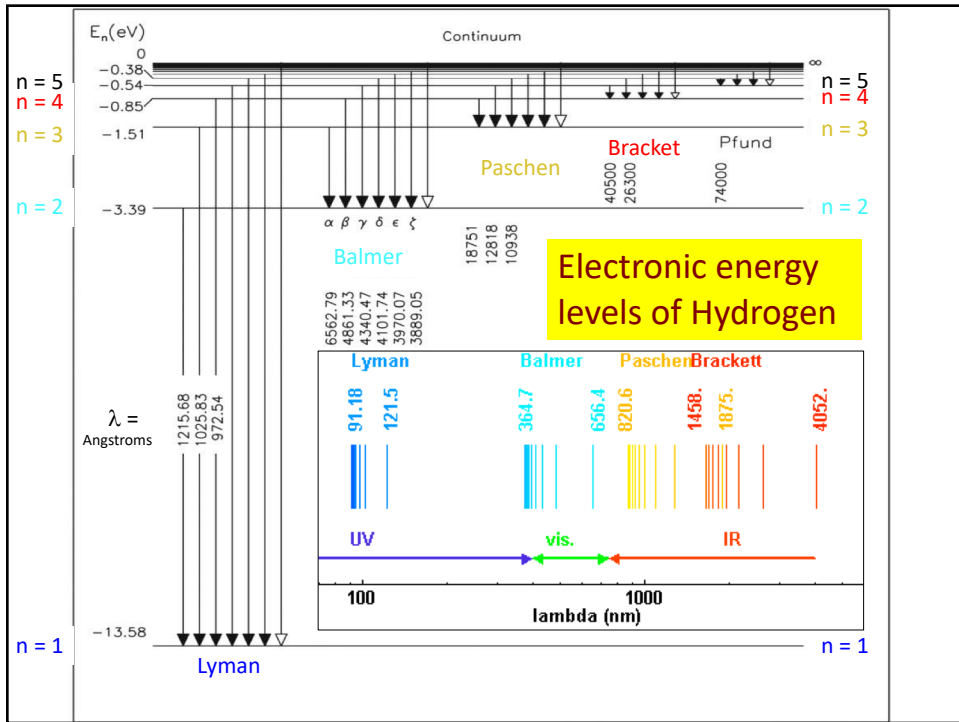
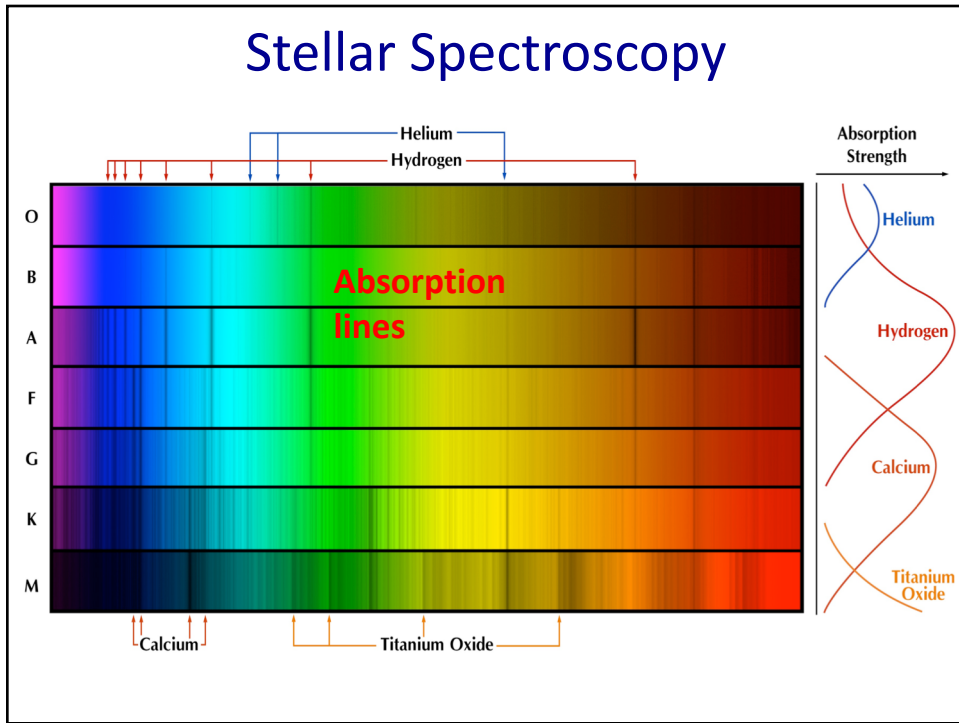
## Spectral Line Transitions



## Atomic Transitions – Galaxy Spectrum



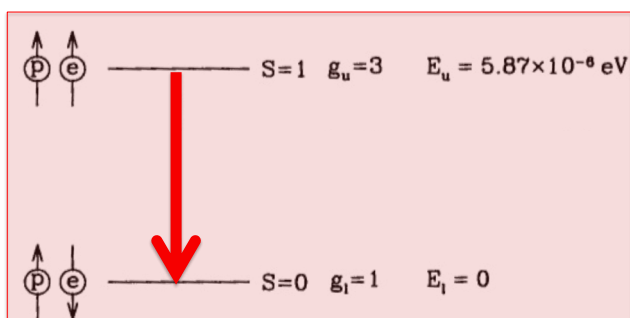
# Stellar Spectroscopy



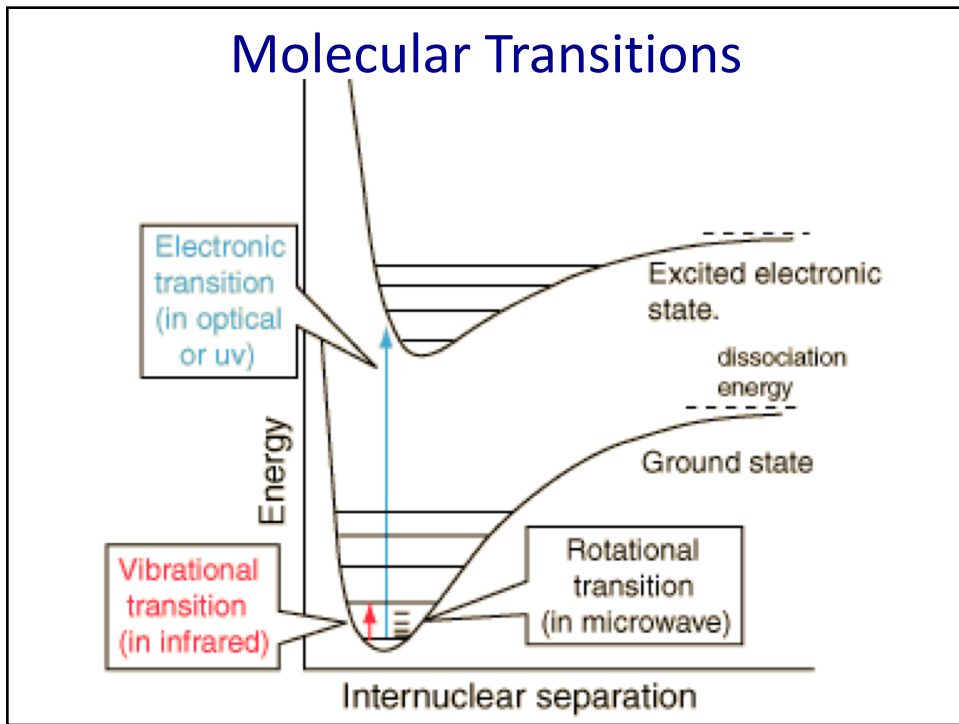
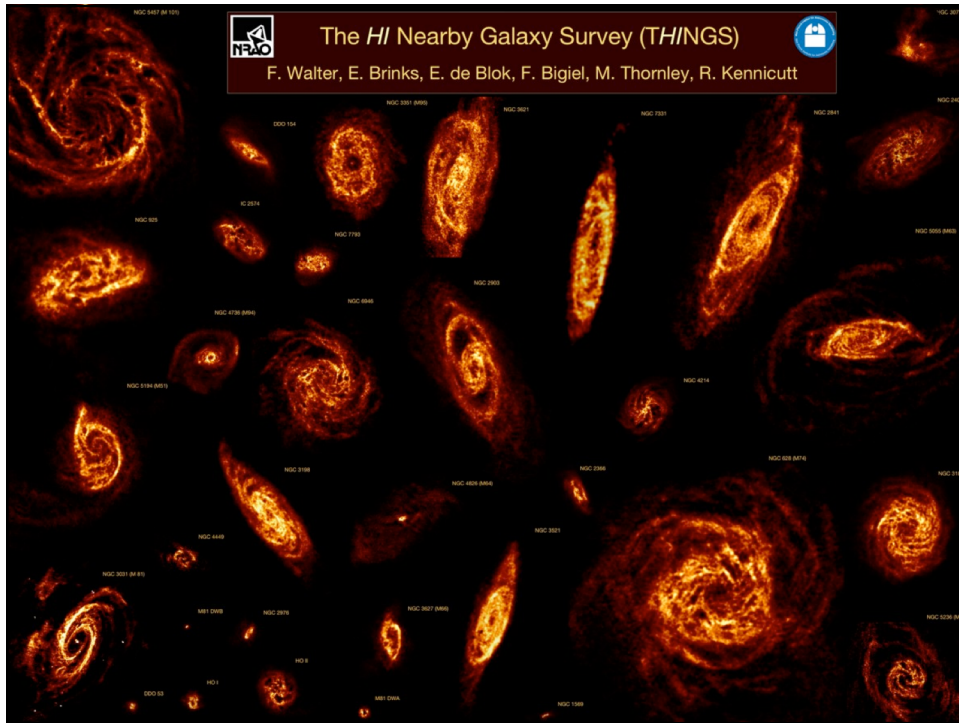


## Atomic Hyperfine Transitions

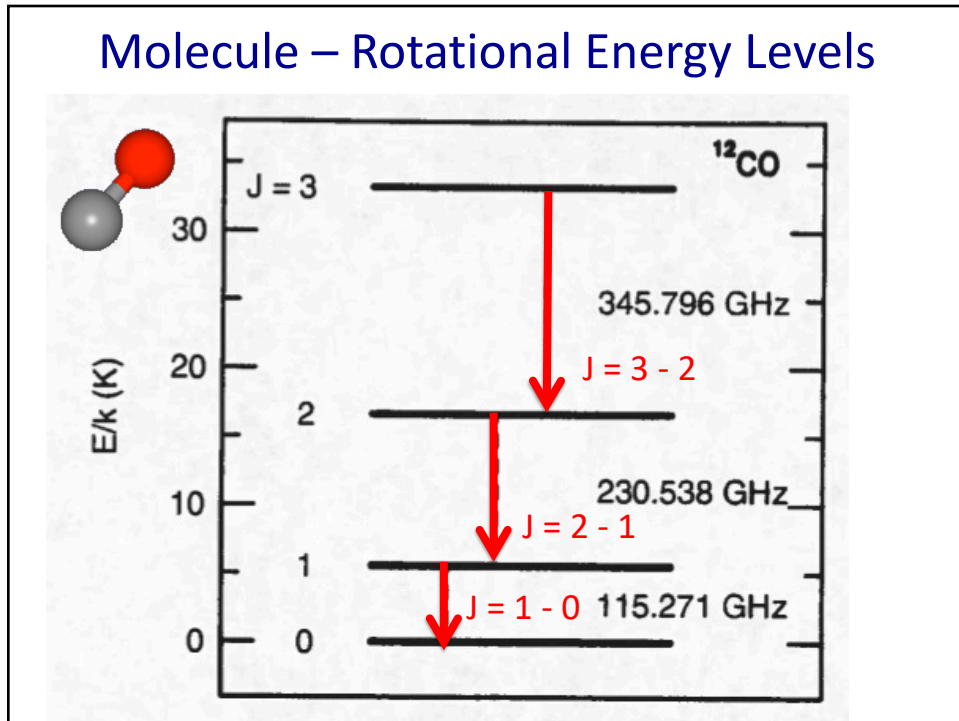
Small splitting of the ground (n=1) electronic state



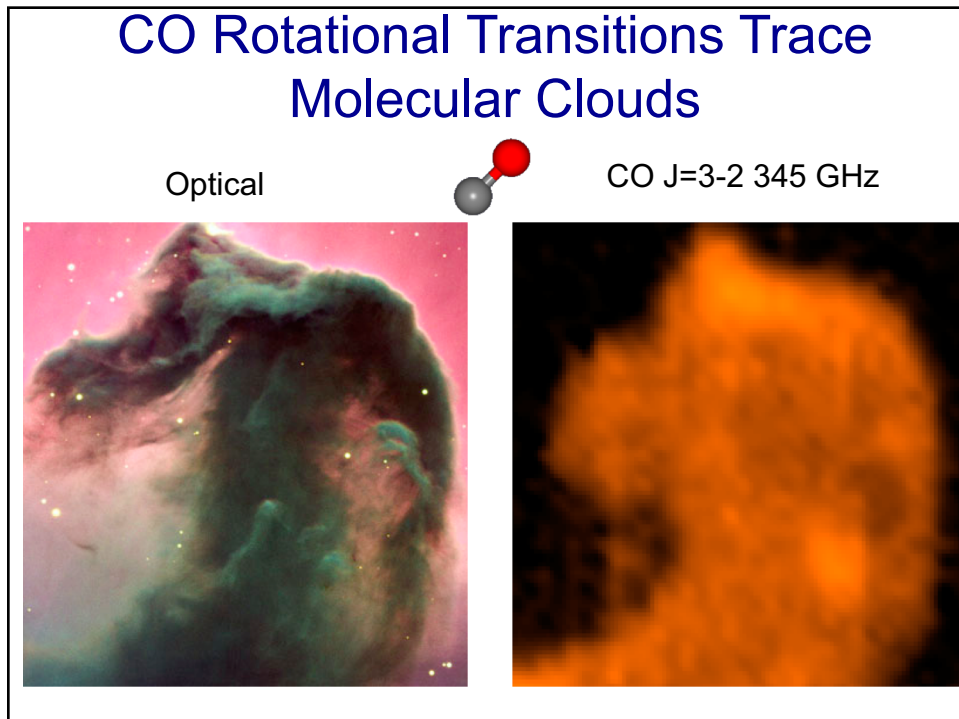
HI 21cm (1.4 GHz) "Spin-flip" transition



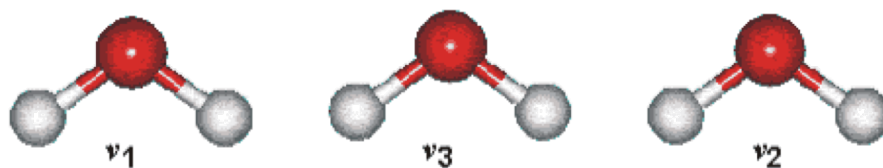
## Molecule – Rotational Energy Levels



## CO Rotational Transitions Trace Molecular Clouds

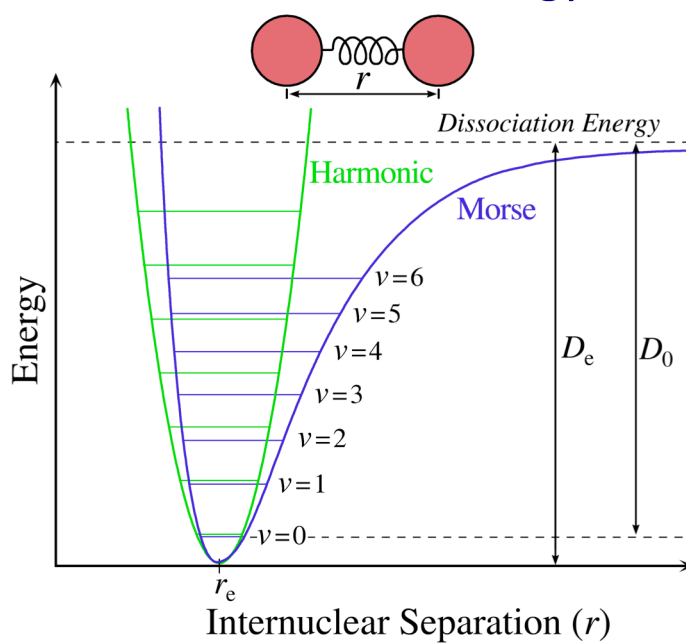


## Molecule – Vibrations H<sub>2</sub>O, CO<sub>2</sub>, CO

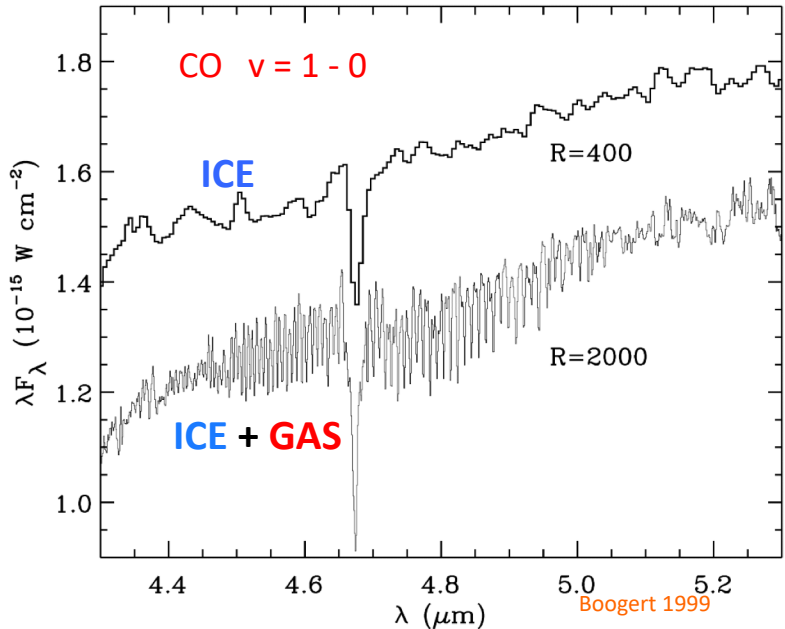


	$\nu_1$ symmetric stretch	$\nu_3$ asymmetric stretch	$\nu_2$ bend
<b>H<sub>2</sub>O</b>	3657 cm <sup>-1</sup> 2.73 $\mu$ m	3756 cm <sup>-1</sup> 2.65 $\mu$ m	1595 cm <sup>-1</sup> 6.27 $\mu$ m
<b>CO<sub>2</sub></b>	x x	2347 cm <sup>-1</sup> 4.26 $\mu$ m	667 cm <sup>-1</sup> 15 $\mu$ m
<b>CO</b>	2143 cm <sup>-1</sup> 4.67 $\mu$ m	x x	x x

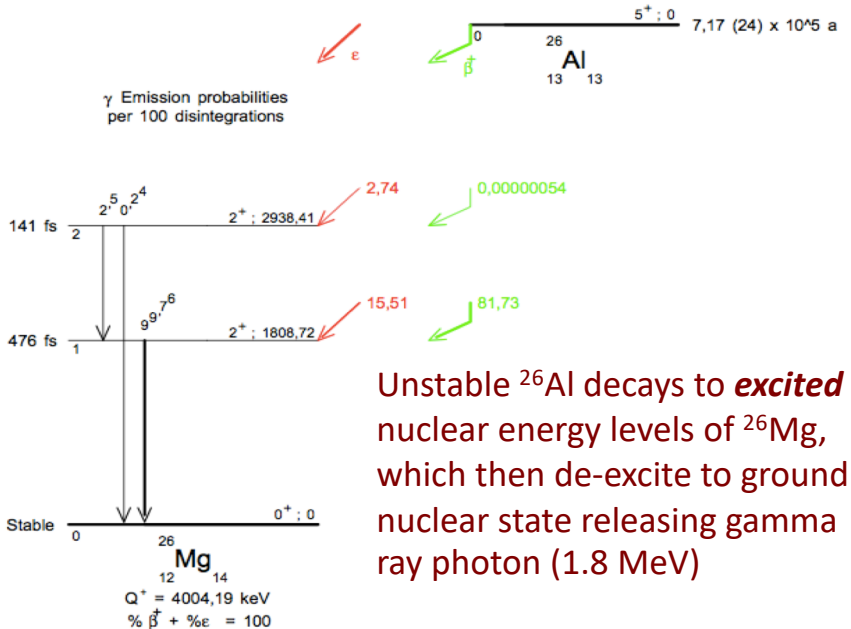
## Molecule Vibrational Energy Levels



### Ro-vibrational Transitions (ice & gas)



### Atomic Nuclear Energy Levels



# 1.809 MeV Gamma Ray Emission

AI26 all-sky map (CGRO-Comptel)

