

# Molecular Astrophysics

- 分子天文物理
- 授課：
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- 週四 2:10PM-5:00PM
- 物207?

# Molecular Astrophysics

- 1 09/13 Chap 1.A brief history; Chap 2. Setting the astronomical scene
- 2 09/20 Chap 3.The tools of the trade
- 3 09/27 Chap 3.The tools of the trade (cont.)
- 4 10/04 Chap 3.The tools of the trade (cont.)
- 5 10/11(?) Chap 4. Chemistry after the Big Bang
- 6 10/18(?) Chap 5. Interstellar clouds - the birthplaces of stars (cont.)
- 7 10/25 Chap 5. Interstellar clouds - the birthplaces of stars (cont.)
- 8 11/01 Chap 5. Interstellar clouds - the birthplaces of stars (cont.)
- 9 11/08 Chap 5. Interstellar clouds - the birthplaces of stars (cont.)

# Molecular Astrophysics (cont'd)

10	11/15	Chap 6. Star formation
11	11/22	Chap 6. Star formation (cont.)
12	11/29	Chap 7. The Solar System at birth
13	12/06	Chap 7. The Solar System at birth (cont.)
14	12/13	Chap 8. Stellar winds and outflows
15	12/20	Chap 8. Stellar winds and outflows (cont.)
16	12/27	Chap 9. Astronomical masers near bright stars
17	01/03	Chap 10. Supernovae: fairly big bangs
18	01/10	Chap 11. Molecules in active galaxies

# References:

- To study over the main reference book, with additional readings of classical journals and updates from recent papers, through presentations and discussions, to understand the first principles related to molecular astrophysics as well as to learn the channels/methods to acquire detailed knowledge in the future.
- Main Reference - “The Chemically Controlled Cosmos”
  - Hartquist and Williams 1995
- Some additional Referenes
  - 分子天體物理學基礎
    - 孫錦 與 李守中 2004
  - Tools of Radio Astronomy
    - Rohlfs and Wilson, 2004 4th Edition

# Rules?

- Grades :
  - attendance/presentation : 70%
  - mid-term exam/final presentation(?) : 30%

# Interstellar Molecules

135 as of February 2005

Red Lettering => IR or UV Detections | Colored Background ==> Isomers

## Molecules with 2 atoms

H <sub>2</sub>	hydrogen molecule	CO	carbon monoxide
CSi	carbon monosilicide	CP	carbon monophosphide
CS	carbon monosulfide	NO	nitric oxide
NS	nitrogen monosulfide	SO	sulfur monoxide
HCl	hydrogen chloride	NaCl	sodium chloride
KCl	potassium chloride	AlCl	aluminum monochloride
AlF	aluminum monofluoride	PN	phosphorus mononitride
SiN	silicon mononitride	SiO	silicon monoxide
SiS	silicon monosulfide	NH	imidyl radical
OH	hydroxyl radical	C <sub>2</sub>	diatomic carbon
CN	cyanide radical	HF	hydrogen fluoride
CO <sup>+</sup>	carbon monoxide ion	SO <sup>+</sup>	sulfur monoxide ion
CH	methylidyne	CH <sup>+</sup>	methyliumylidene
SH	mercapto radical	LiH	lithium hydride
FeO	iron oxide	N <sub>2</sub>	diatomic nitrogen

## Molecules with 3 atoms

H <sub>2</sub> O	water	H <sub>2</sub> S	hydrogen sulfide
HCN	hydrogen cyanide	HNC	hydrogen isocyanide
CO <sub>2</sub>	carbon dioxide	SO <sub>2</sub>	sulfur dioxide
MgCN	magnesium cyanide	MgNC	magnesium isocyanide
NaCN	sodium cyanide	N <sub>2</sub> O	nitrous oxide
NH <sub>2</sub>	amidyl radical	OCS	carbonyl sulfide
HCO	formyl radical	C <sub>3</sub>	triatomic carbon
C <sub>2</sub> H	ethynyl radical	HCO <sup>+</sup>	formyl ion
HOC <sup>+</sup>	hydroxymethylidyne	N <sub>2</sub> H <sup>+</sup>	dinitrogen monohydride ion
HNO	nitrosyl hydride	HCS <sup>+</sup>	thiooxomethylum
H <sub>3</sub> <sup>+</sup>	hydrogen ion	C <sub>2</sub> O	ketenylidene
C <sub>2</sub> S	thioxothenylidene	SiC <sub>2</sub>	silicon dicarbide
AlNC	aluminum isocyanide	CH <sub>2</sub>	methylene
SiCN	silicon monocyanide	SiNC	silicon isocyanide

Molecules with 4 atoms			
NH <sub>3</sub>	ammonia	H <sub>2</sub> CO	formaldehyde
H <sub>2</sub> CS	thioformaldehyde	C <sub>2</sub> H <sub>2</sub>	acetylene
HNCO	isocyanic acid	HNCS	thioisocyanic acid
H <sub>3</sub> O <sup>+</sup>	hydronium ion	HOCO <sup>+</sup>	protonated carbon dioxide
C <sub>3</sub> S	1,2-propadienylidene, 3-thioxo	H <sub>2</sub> CN	methylene amidogen
c-C <sub>3</sub> H	cyclopropenylidyne	l-C <sub>3</sub> H	2-propynylidyne
HCCN	cyanomethylene	C <sub>3</sub> O	tricarbon monoxide
C <sub>2</sub> CN	cyanoethynyl	SiC <sub>3</sub>	Rhomboidal SiC <sub>3</sub>
HCNH <sup>+</sup>	iminomethylum	CH <sub>3</sub>	methyl radical
Molecules with 5 atoms			
CH <sub>4</sub>	methane	SiH <sub>4</sub>	silane
CH <sub>2</sub> NH	methyleneimine	NH <sub>2</sub> CN	cyanamide
CH <sub>2</sub> CO	ketene	HCOOH	formic acid
HC <sub>3</sub> N	cyanoacetylene	HC <sub>2</sub> NC	isocyanoacetylene
c-C <sub>3</sub> H <sub>2</sub>	cyclopropenylidene	l-C <sub>3</sub> H <sub>2</sub>	propenylidene
CH <sub>2</sub> CN	cyanomethyl radical	C <sub>4</sub> H	1,3-butadiynyl radical
C <sub>4</sub> Si	silicon tetracarbide	C <sub>5</sub>	pentacarbon molecule
HNC <sub>3</sub>	1,2-propadienylidene, -3-imino	H <sub>2</sub> COH <sup>+</sup>	protonated formaldehyde
Molecules with 6 atoms			
CH <sub>3</sub> OH	methanol	CH <sub>3</sub> SH	methanethiol
H <sub>2</sub> CCH <sub>2</sub>	ethylene	HCCCCH	diacetylene
CH <sub>3</sub> CN	methyl cyanide	CH <sub>3</sub> NC	methylisocyanide
HCONH <sub>2</sub>	formamide	HC <sub>2</sub> CHO	propynal
C <sub>5</sub> H	2,4-pentadiynylidyne	HC <sub>3</sub> NH <sup>+</sup>	protonated 2-propynenitrile
C <sub>5</sub> N	1,3-butadiynylium, 4-cyano	H <sub>2</sub> CCCC	butatrienylidene
HC <sub>4</sub> N	3-cyano 2-propynylidene		

Molecules with 7 atoms			
CH <sub>3</sub> CCH	methyl acetylene	CH <sub>3</sub> CHO	acetaldehyde
CH <sub>3</sub> NH <sub>2</sub>	methylamine	CH <sub>2</sub> CHCN	vinyl cyanide
HC <sub>5</sub> N	cyanobutadiyne	C <sub>6</sub> H	1,3,5-hexatriynl
c-C <sub>2</sub> H <sub>4</sub> O	ethylene oxide	CH <sub>2</sub> CHOH	vinyl alcohol
Molecules with 8 atoms			
CH <sub>3</sub> COOH	acetic acid	CH <sub>3</sub> OCHO	methyl formate
CH <sub>3</sub> C <sub>3</sub> N	cyanomethylacetylene	CH <sub>2</sub> (OH)CHO	glycolaldehyde
H <sub>2</sub> C <sub>6</sub>	hexapentaenylidene	HC <sub>6</sub> H	triacetylene
C <sub>2</sub> H <sub>6</sub>	ethane	C <sub>7</sub> H	2,4,6-heptatriynylidyne
CH <sub>2</sub> CHCHO	propenal		
Molecules with 9 atoms			
(CH <sub>3</sub> ) <sub>2</sub> O	dimethyl ether	CH <sub>3</sub> CH <sub>2</sub> OH	ethanol
CH <sub>3</sub> CH <sub>2</sub> CN	ethyl cyanide	CH <sub>3</sub> C <sub>4</sub> H	methylbutadiyne
HC <sub>7</sub> N	cyanohexatriyne	C <sub>8</sub> H	1,3,5,7-octateraynyl
Molecules with 10 atoms			
(CH <sub>3</sub> ) <sub>2</sub> CO	acetone	HOCH <sub>2</sub> CH <sub>2</sub> OH	ethylene glycol
CH <sub>3</sub> CH <sub>2</sub> CHO	propanal	CH <sub>3</sub> C <sub>5</sub> N	methylcyano diacetylene
Molecules with 11 atoms			
HC <sub>9</sub> N	cyanooctatetrayne		
Molecules with 12 atoms			
C <sub>6</sub> H <sub>6</sub>	benzene		
Molecules with 13 atoms			
HC <sub>11</sub> N	cyanodecapentayne		

courtesy of J. Hollis