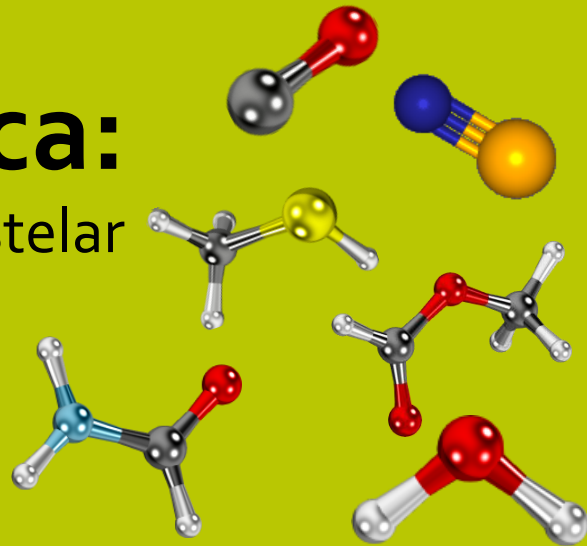


Astroquímica:

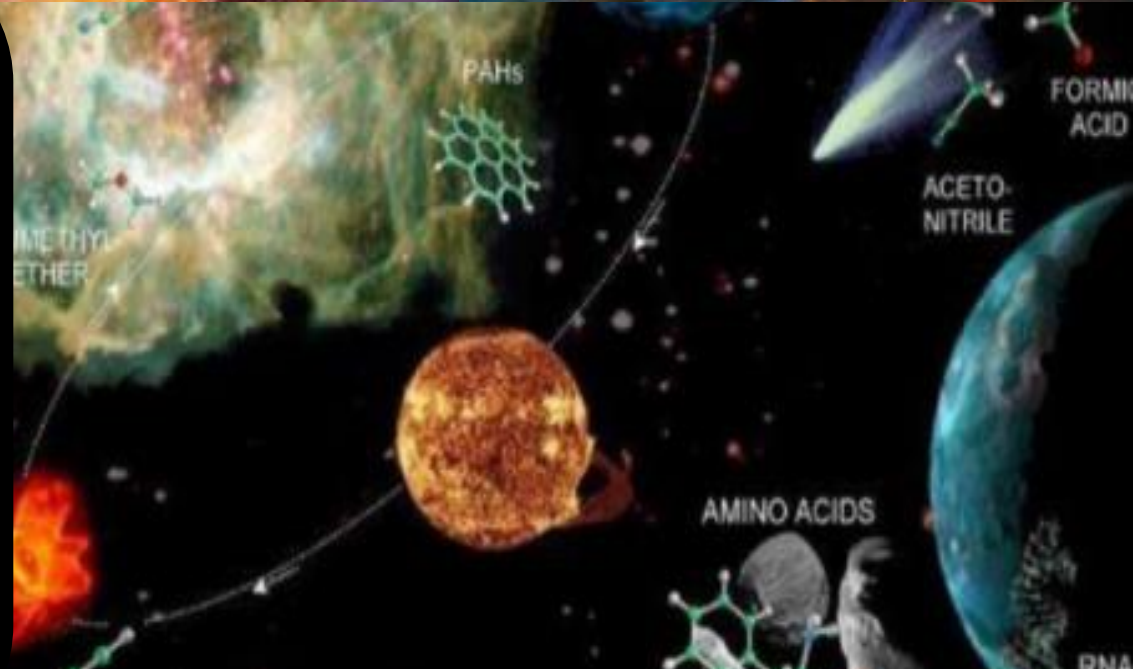
De la nucleosíntesis estelar
a la complejidad
molecular



Heidy M. Quitián-Lara

D.Sc. Astronomía.

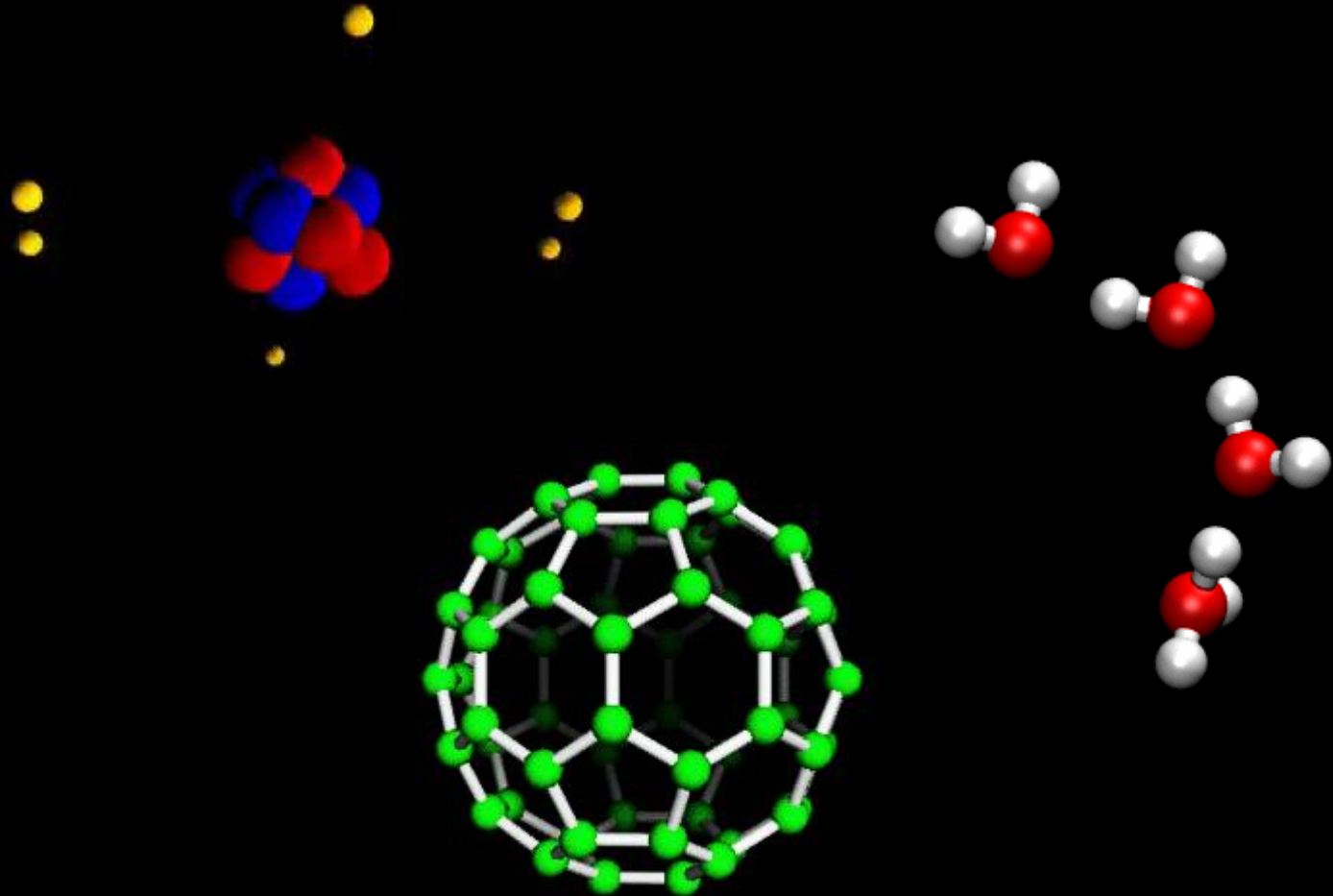
Julius-Maximilians-Universität Würzburg (Alemania)

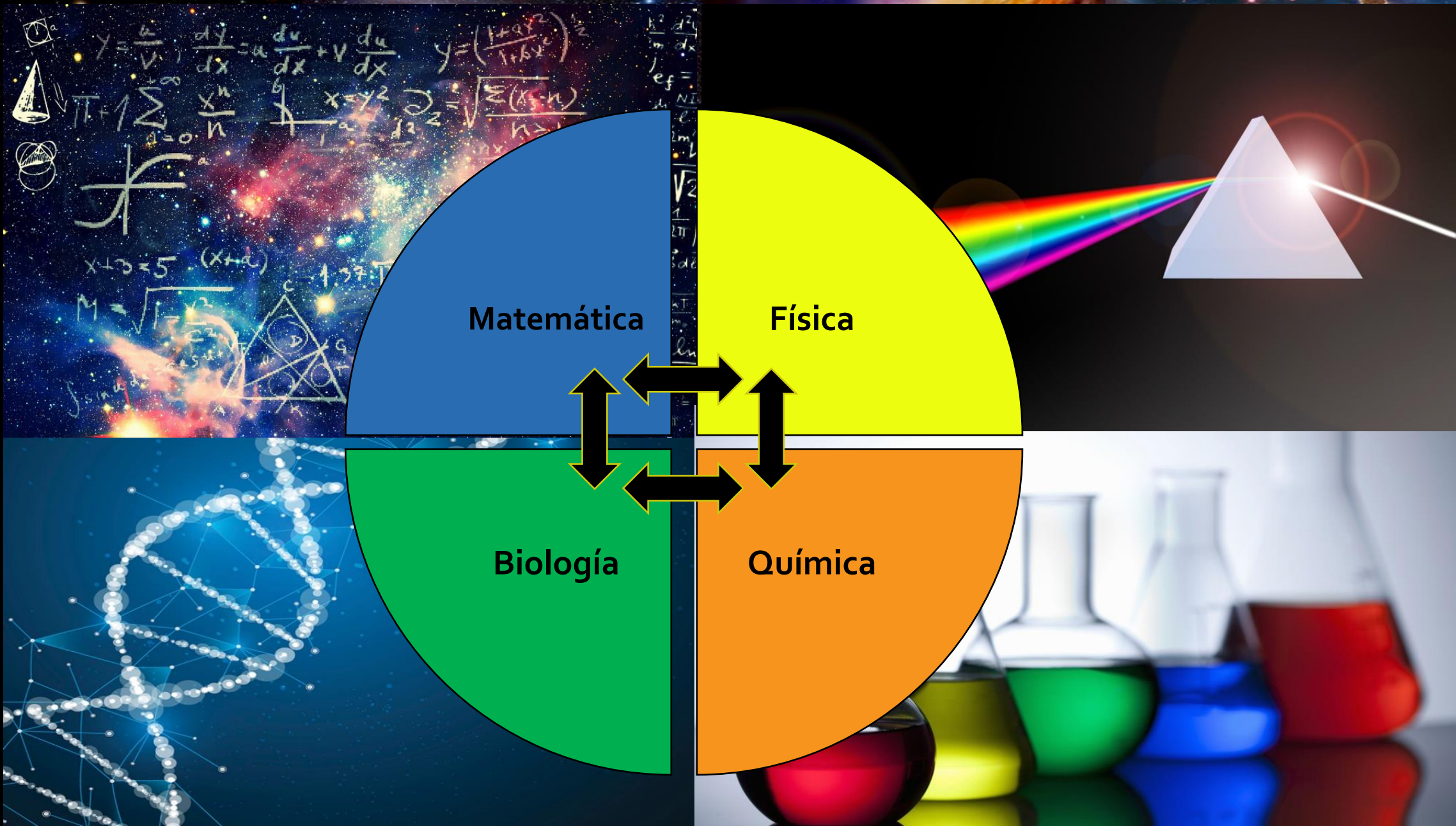


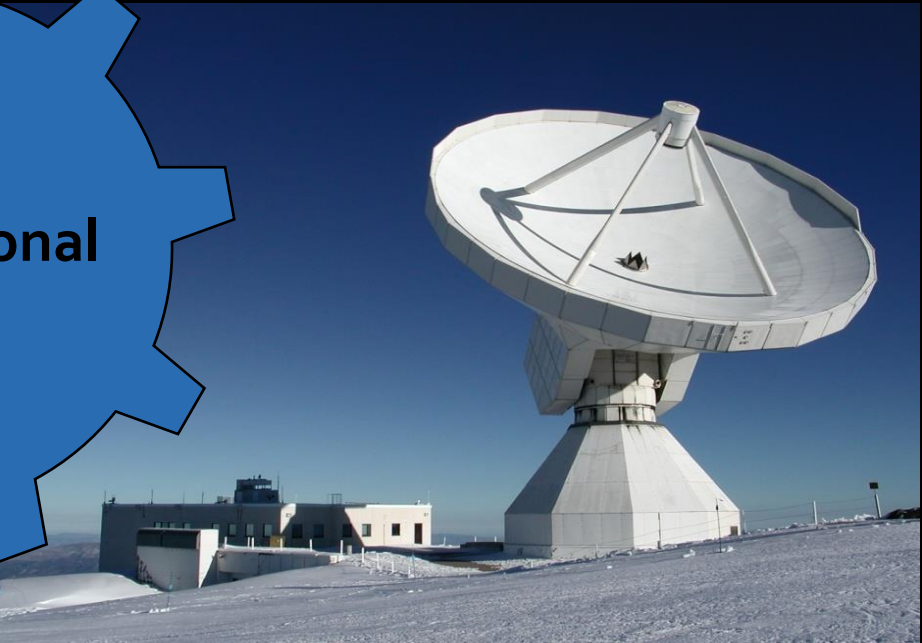
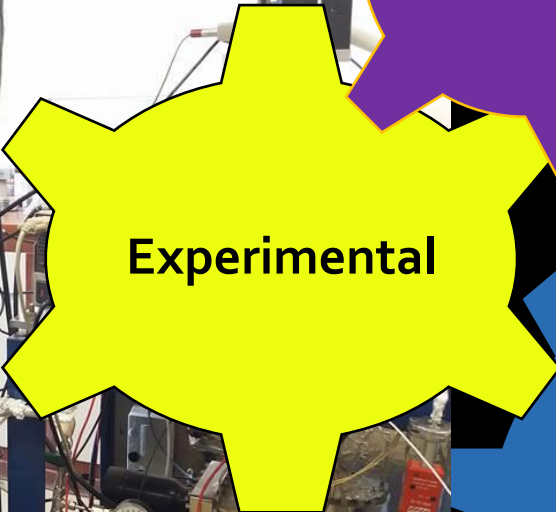
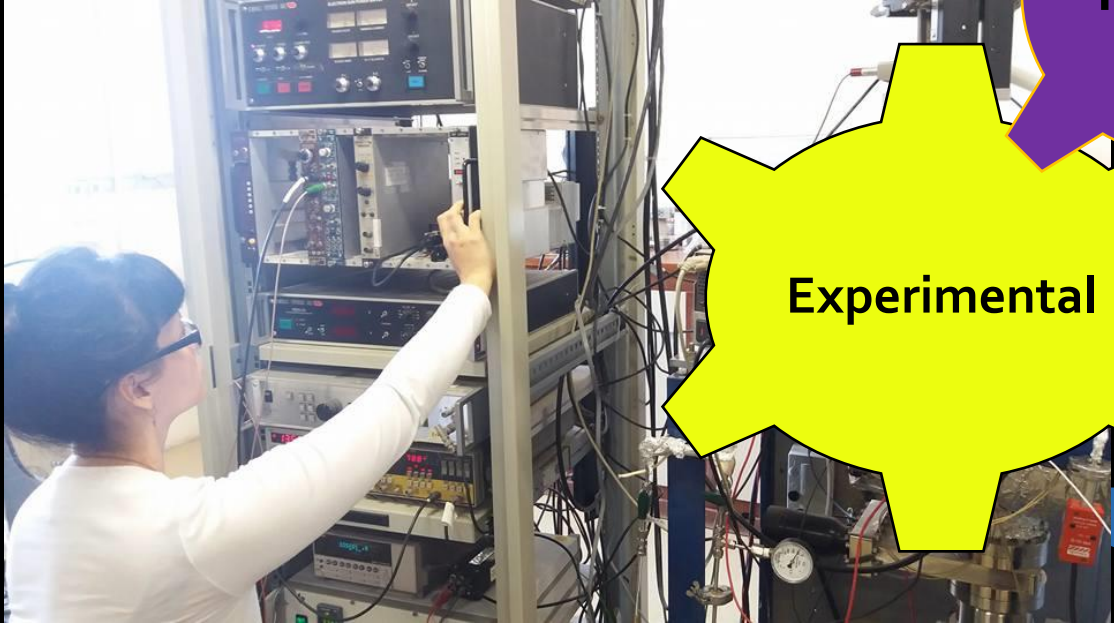
ASTROQUÍMICA (COSMOQUÍMICA)

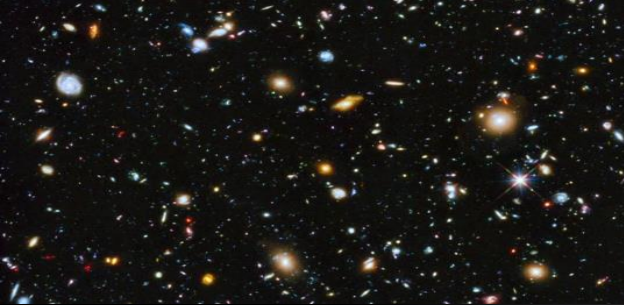
Composición química
de la materia del
Universo.

- Elementos
- Moléculas









UNIVERSO ATÓMICO

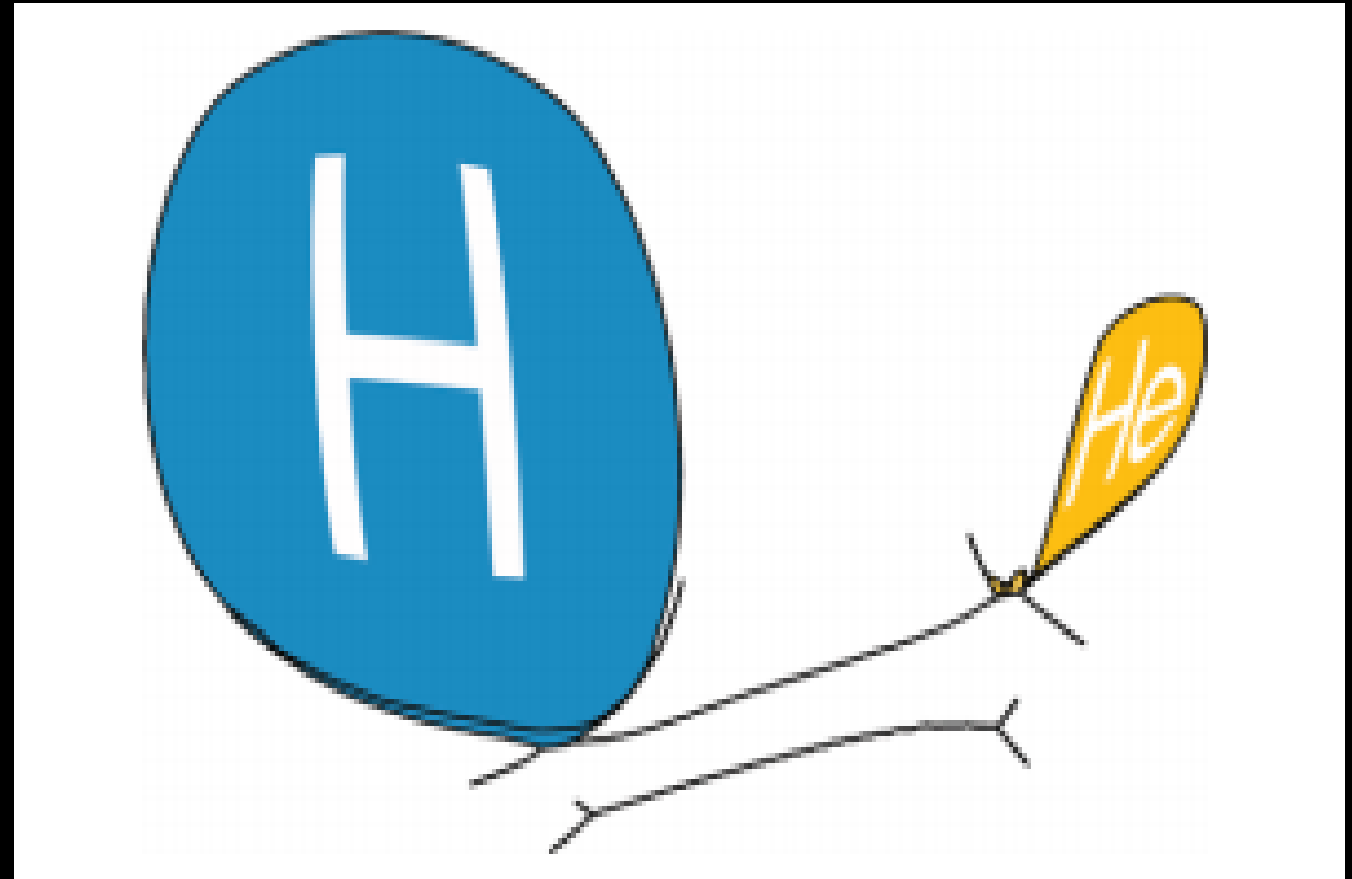


FORMACIÓN DE LOS ELEMENTOS QUÍMICOS

Abundancias semejantes:

- Sistema solar
 - Estrellas
 - Nebulosas
 - Galaxias

H	1	S	1.6×10^{-5}
He	0.085	P	3.2×10^{-7}
Li	1.5×10^{-9}	Mg	3.5×10^{-5}
C	3.7×10^{-3}	Na	1.7×10^{-6}
N	1.2×10^{-3}	K	1.1×10^{-7}
O	6.7×10^{-3}	Si	3.6×10^{-6}



M. Winter, *J. Chem. Educ.* 2011.

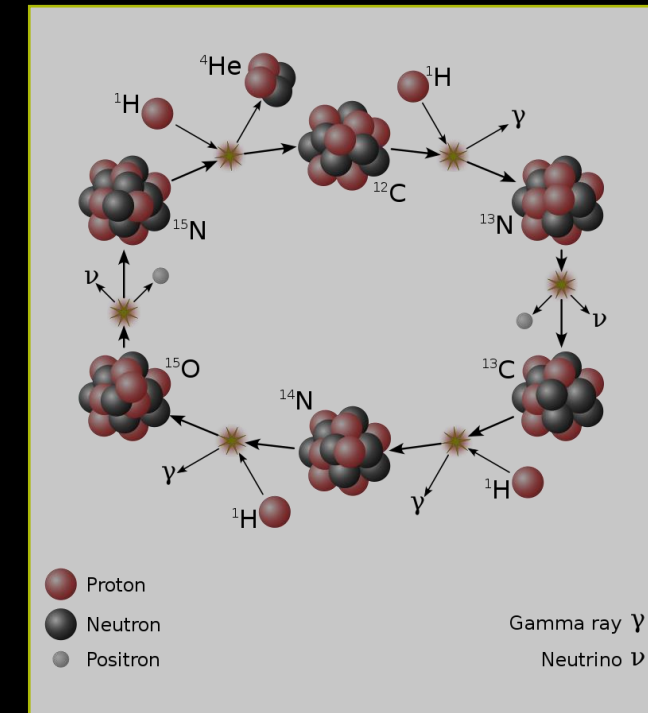
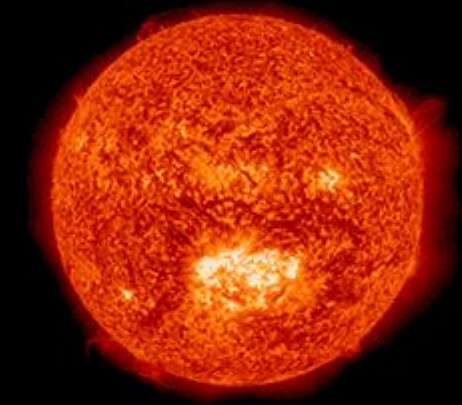
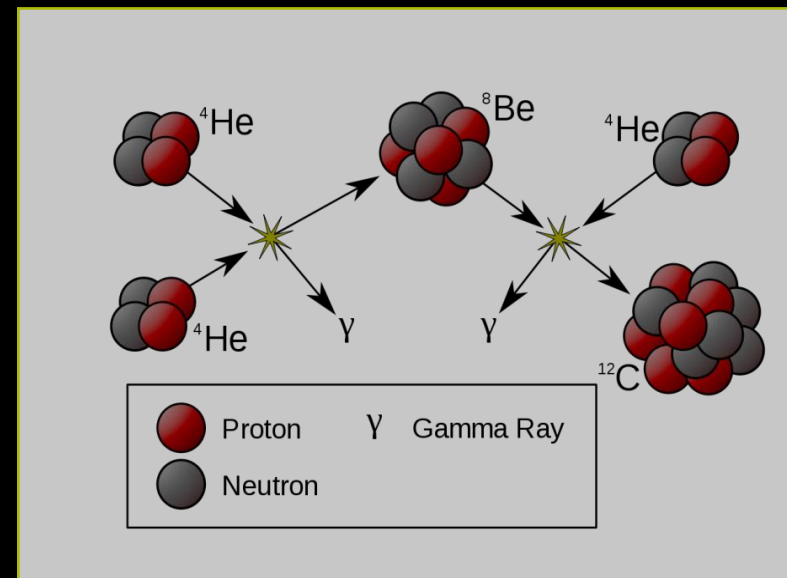
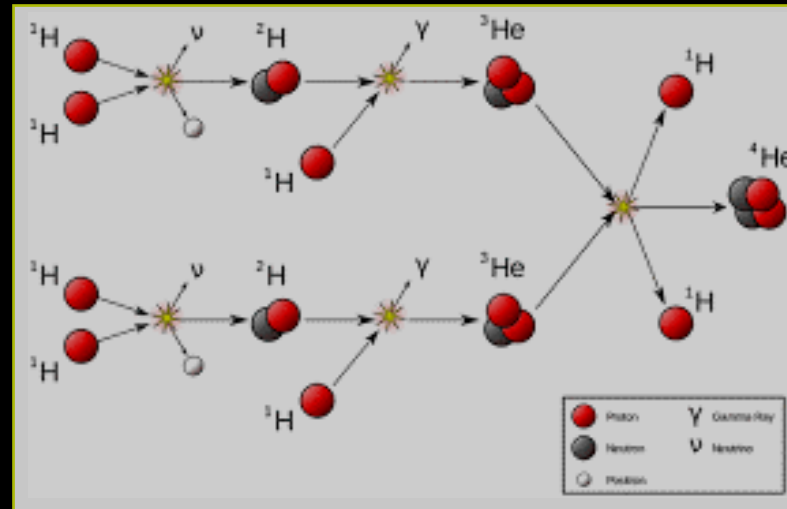
Shaw, A. *Astrochemistry From Astronomy to Astrobiology*, Wiley & Sons, 2006.

NUCLEOSÍNTESIS: FORMACIÓN DE LOS ELEMENTOS QUÍMICOS

Nucleosíntesis *quiescente*

- Fusión de núcleos atómicos
- Generación de energía como subproducto.

(Cadena P-P, Ciclo CNO, Triple α , procesos-s,p)

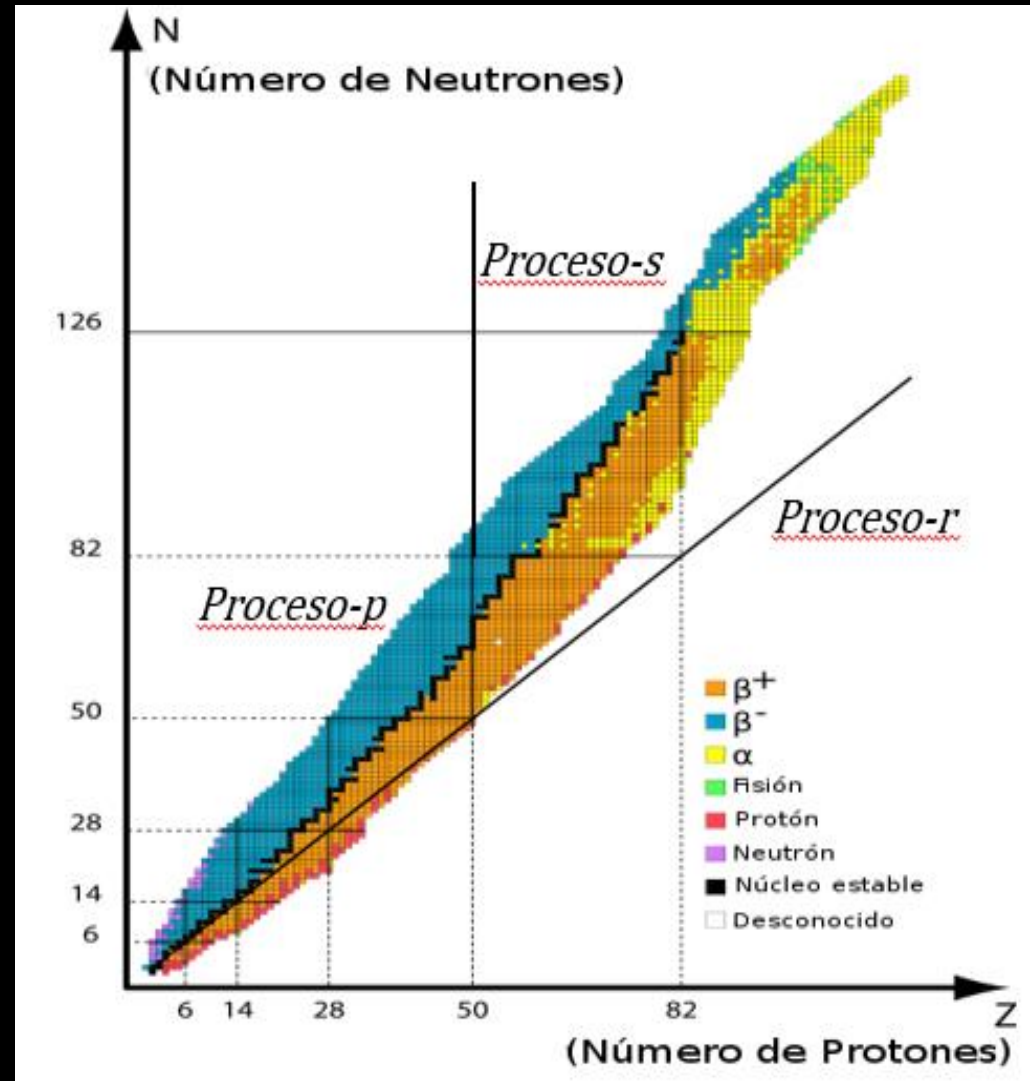


NUCLEOSÍNTESIS: FORMACIÓN DE LOS ELEMENTOS QUÍMICOS

Nucleosíntesis explosiva

- Captura de neutrones
- Generación de energía
Decaimientos.

(Proceso-r)





UNIVERSO MOLECULAR

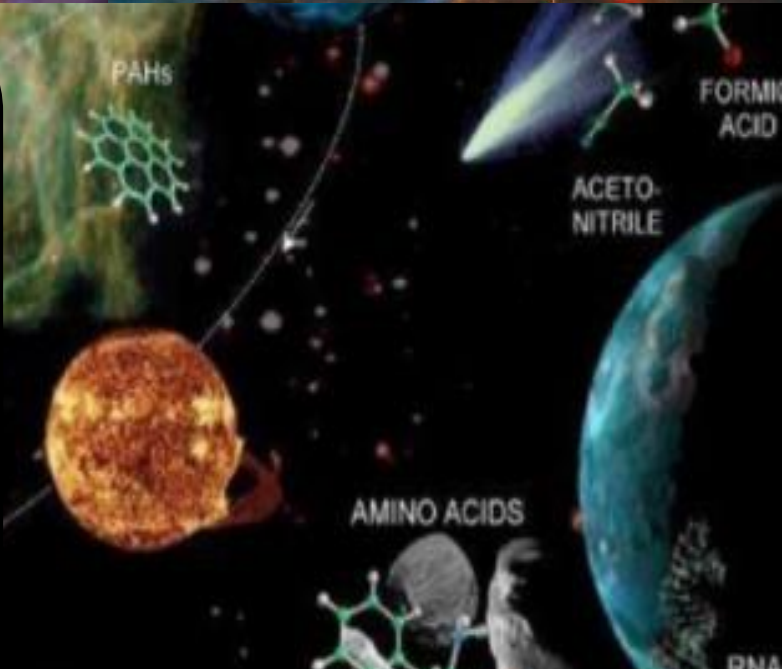


Table 1. Organic Molecules Detected between 1969 and 1979.

SPACIO

Table 3. Organic Molecules Detected in the 1990s.

Table 4. Organic Molecules Detected between 2000 and 2015.

Year Reported	Spec
1990	none
1991	C ₂ O
1992	HCC
1993	none
1994	C ₆₀ ⁺
1995	CH ₂
1996	C ₈ H
1997	<i>l</i> -C ₆
1998	C ₅ N
1999	none

Year Reported	Species			
2000	CH ₂ OHCHO [77]	CH ₃ [78]		
2001	<i>c</i> -C ₆ H ₆ [79]	CH ₂ CHOH [80]	<i>l</i> -HC ₄ H [79]	<i>l</i> -HC ₆ H [79]
2002	(CH ₂ OH) ₂ [81]			
2003	none			
2004	CH ₂ CHCHO ? [82]	CH ₃ CH ₂ CHO [82]	<i>l</i> -HC ₄ N [83]	
2005	C ₂ H ₅ OCH ₃ ? [84]			
2006	<i>c</i> -H ₂ C ₃ O [85]	CH ₂ CCHCN [86]	CH ₂ CNH ? [87]	CH ₃ C ₅ N [88]
	CH ₃ CONH ₂ [89]	C ₆ H ⁻ [90]		
2007	C ₄ H ⁻ [91]	C ₈ H ⁻ [92]	CH ₂ CHCH ₃ [93]	
2008	HCOCN [94]	NH ₂ CH ₂ CN [95]		
2009	C ₂ H ₅ OCHO [96]	HCNO [97]	HOCN [98]	HSCN [99]
	<i>n</i> -C ₃ H ₇ CN [96]			
2010	C ₆₀ [100]	C ₇₀ [100]		
2011	none			
2012	CH ₃ O [101]	HNCNH [102]		
2013	CH ₃ CHNH [103]	CH ₃ COOCH ₃ [104]	H ₂ CNO ⁺ ? [105]	HNCHCN [106]
2014	C ₂ N [107]	CH ₃ CH ₂ SH ? [108]	<i>i</i> -C ₃ H ₇ CN [109]	
2015	CH ₃ NCO [110]	HCCO [111]	NCCNH ⁺ [112]	

Masatoshi Ohishi 2016
 J. Phys.: Conf. Ser. 728
 052002

MOLÉCULAS IDENTIFICADAS EL ESPACIO

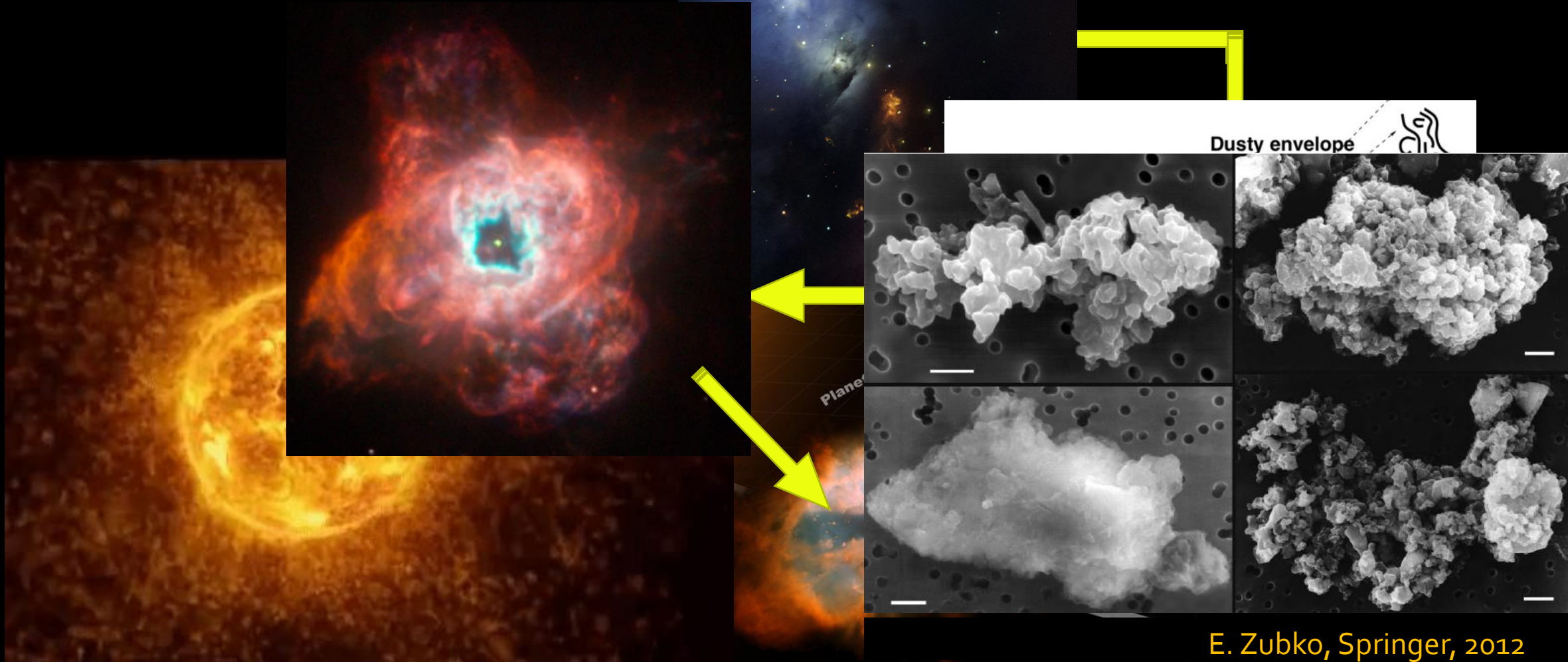
2 atoms	3 atoms	4 atoms	5 atoms	6 atoms	7 atoms	8 atoms	9 atoms	10 atoms	11 atoms	12 atoms	>12 atoms
H ₂	C ₃ [*]	<i>o</i> -C ₃ H	C ₅ [*]	C ₅ H	C ₆ H	CH ₃ C ₃ N	CH ₃ C ₄ H	CH ₃ C ₅ N	HC ₉ N	<i>o</i> -C ₆ H ₆ [*]	C ₆₀ [*]
AlF	C ₂ H	<i>l</i> -C ₃ H	C ₄ H	<i>l</i> -H ₂ C ₄	CH ₂ CHCN	HC(O)OCH ₃	CH ₃ CH ₂ CN	(CH ₃) ₂ CO	CH ₃ C ₆ H	<i>n</i> -C ₃ H ₇ CN	C ₇₀ [*]
AlCl	C ₂ O	C ₃ N	C ₄ Si	C ₂ H ₄ [*]	CH ₃ C ₂ H	CH ₃ COOH	(CH ₃) ₂ O	(CH ₂ OH) ₂	C ₂ H ₅ OCHO	<i>i</i> -C ₃ H ₇ CN	C ₆₀ ^{**}
C ₂ ^{**}	C ₂ S	C ₃ O	<i>l</i> -C ₃ H ₂	CH ₃ CN	HC ₅ N	C ₇ H	CH ₃ CH ₂ OH	CH ₃ CH ₂ CHO	CH ₃ OC(O)CH ₃	C ₂ H ₅ OCH ₃ ?	<i>o</i> -C ₆ H ₅ CN 2018
CH	CH ₂	C ₃ S	<i>o</i> -C ₃ H ₂	CH ₃ NC	CH ₃ CHO	C ₆ H ₂	HC ₇ N	CH ₃ CHCH ₂ O			
CH ⁺	HCN	C ₂ H ₂ [*]	H ₂ CCN	CH ₃ OH	CH ₃ NH ₂	CH ₂ OHCHO	C ₈ H	CH ₃ OCH ₂ OH 2017			
CN	HCO	NH ₃	CH ₄ [*]	CH ₃ SH	<i>o</i> -C ₂ H ₄ O	<i>l</i> -HC ₆ H [*]	CH ₃ C(O)NH ₂				
CO	HCO ⁺	HCCN	HC ₃ N	HC ₃ NH ⁺	H ₂ CCHOH	CH ₂ CHCHO (?)	C ₈ H ⁻				
CO ⁺	HCS ⁺	HCNH ⁺	HC ₂ NC	HC ₂ CHO	C ₆ H ⁻	CH ₂ CCHCN	C ₃ H ₆				
CP	HOC ⁺	HNCO	HCOOH	NH ₂ CHO	CH ₃ NCO	H ₂ NCH ₂ CN	CH ₃ CH ₂ SH (?)				
SiC	H ₂ O	HNCS	H ₂ CNH	C ₅ N	HC ₅ O 2017	CH ₃ CHNH	CH ₃ NHCHO ? 2017				
HCl	H ₂ S	HOCO ⁺	H ₂ C ₂ O	<i>l</i> -HC ₄ H [*]	HOCH ₂ CN 2019	CH ₃ SiH ₃ 2017	HC ₇ O 2017				
KCl	HNC	H ₂ CO	H ₂ NCN	<i>l</i> -HC ₄ N							

“Molecules in Space | I. Physikalisches Institut”

The background is a collage of various space-related images. At the top left is a vertical strip of the Milky Way galaxy. To its right are several panels: a field of stars, a face-on spiral galaxy, a glowing nebula with orange and purple hues, and a colorful nebula with a central star. Below these are panels showing molecular structures with labels: 'PAHs', 'FORMIC ACID', 'ACETO-NITRILE', 'AMINO ACIDS', and 'DNA'. At the bottom are panels showing a colorful nebula, a red and white nebula, a protoplanetary disk, and a landscape with a volcano and a lake under a sunset sky.

LOCALES DE FORMACIÓN MOLECULAR

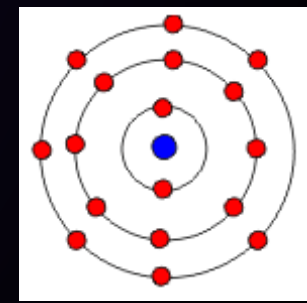
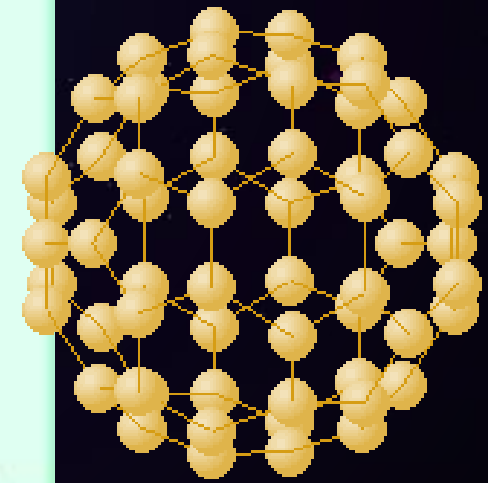
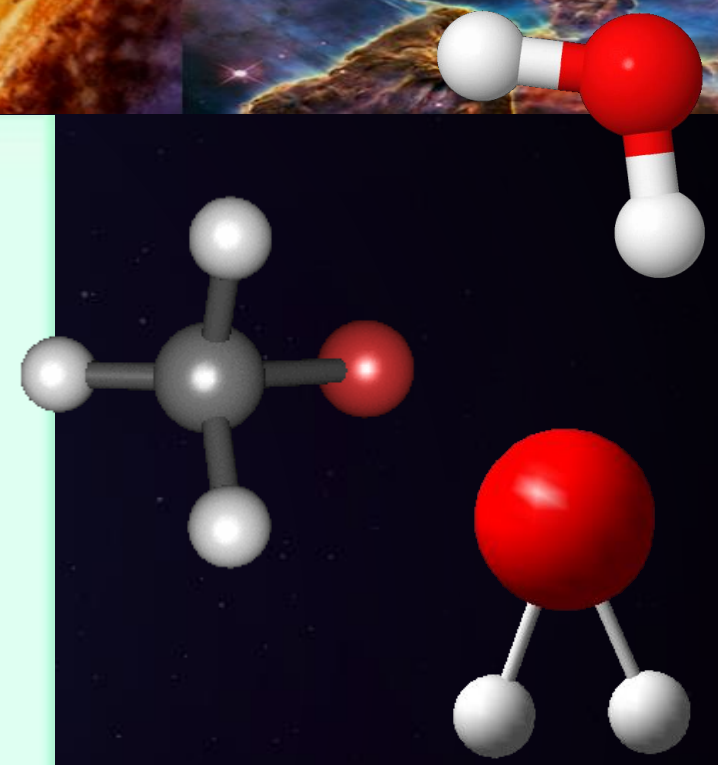
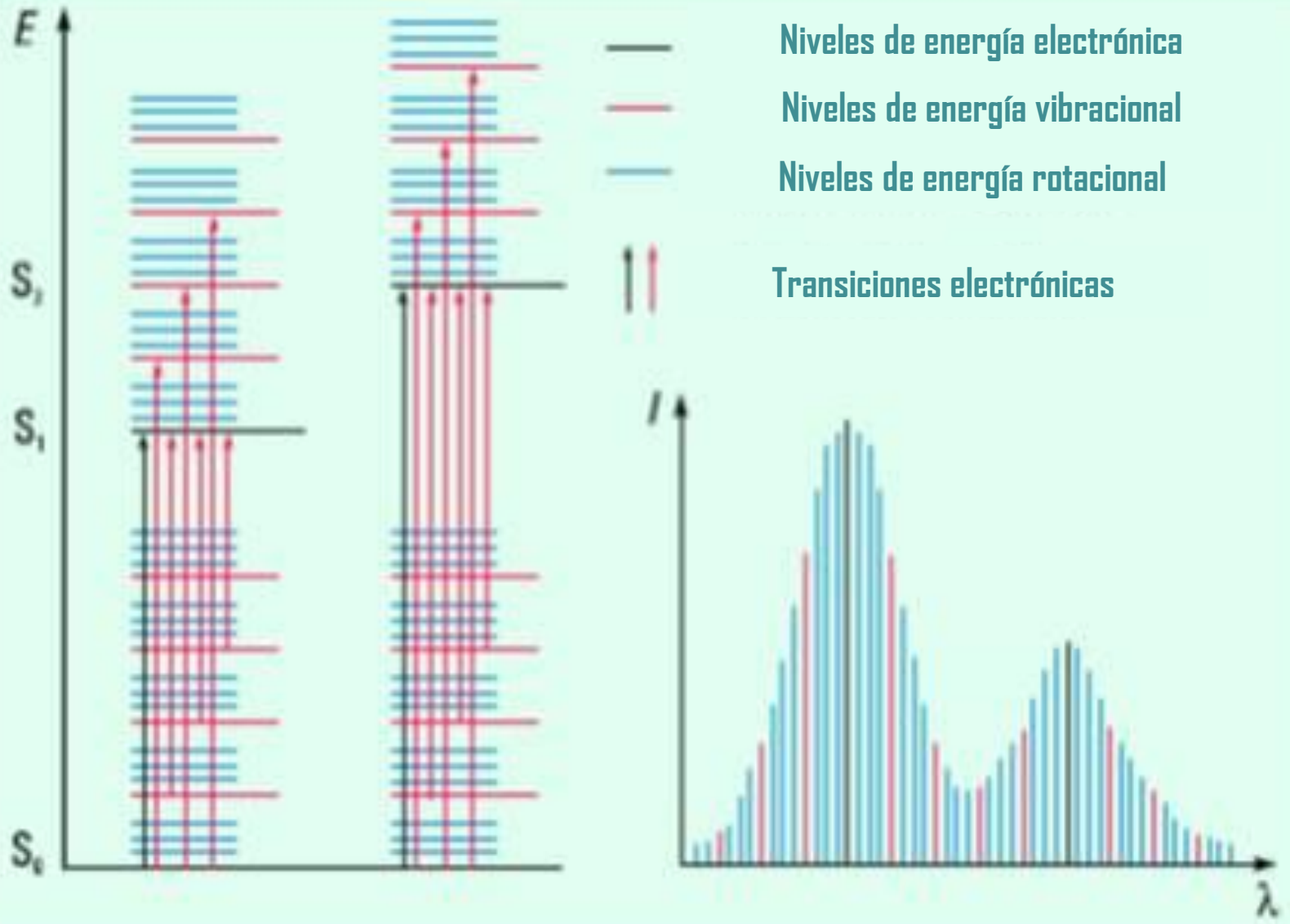
FORMACIÓN MOLECULAR



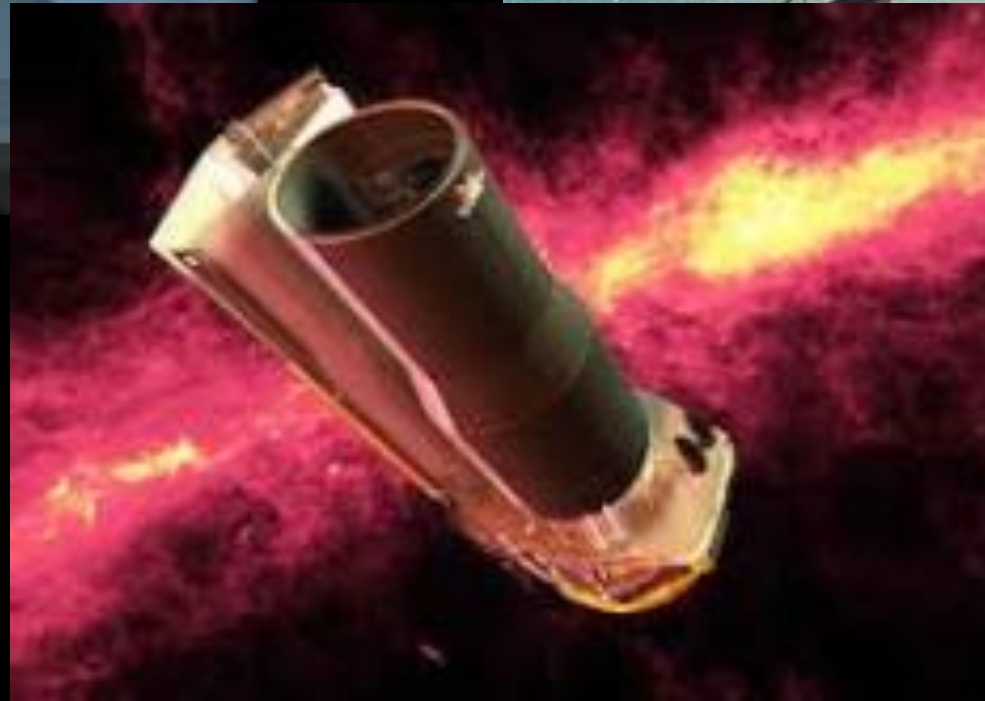
E. Zubko, Springer, 2012



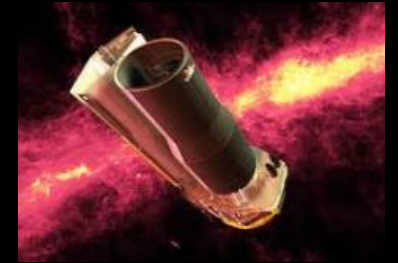
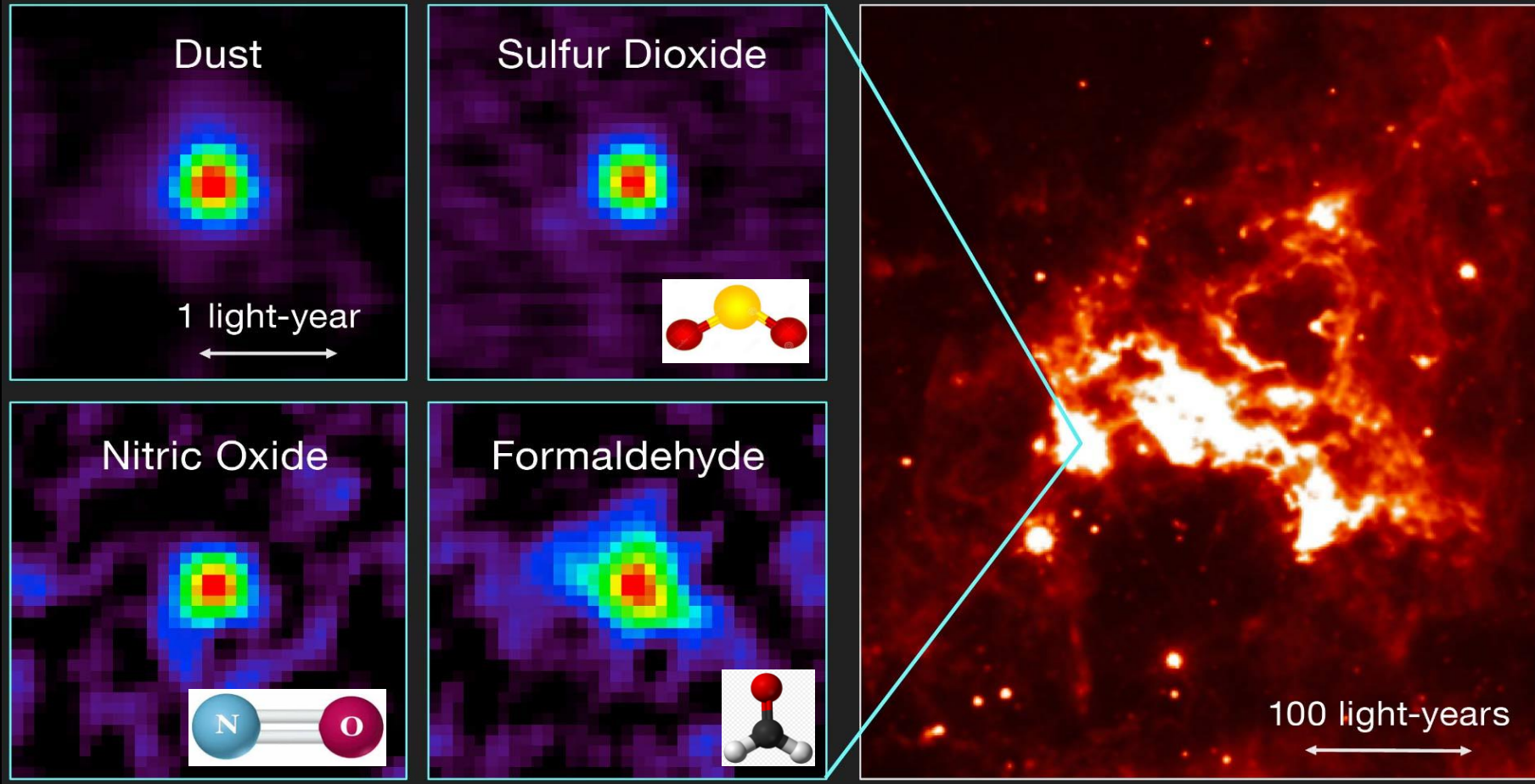
Metodologías en Astroquímica



ASTROQUÍMICA OBSERVACIONAL

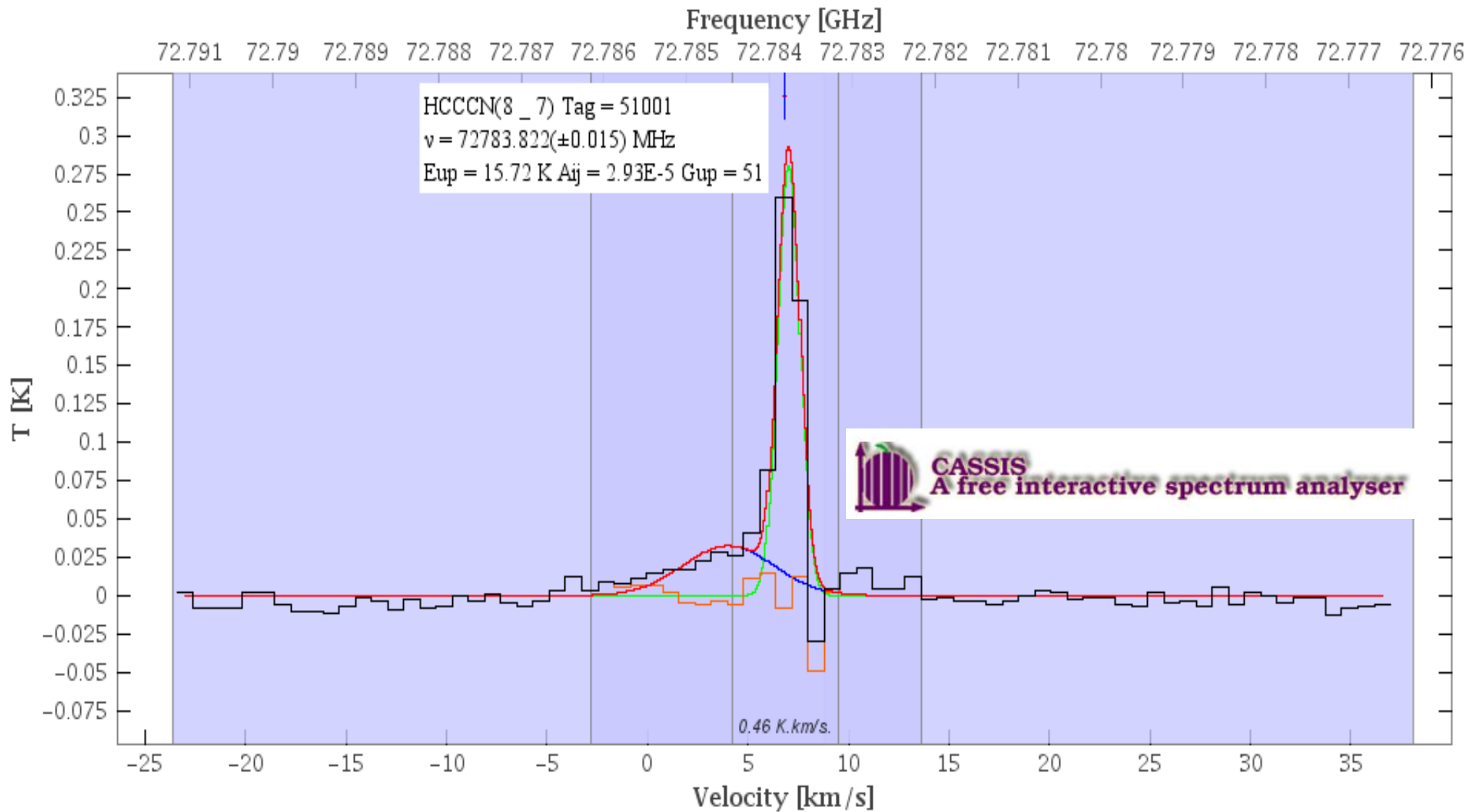


MAPEO - MORFOLOGÍA



Observaciones del primer núcleo caliente (hot core) encontrado fuera de la vía láctea .
ALMA (2016). Objeto ST11 , Grande Nube de Magallanes.

ESPECTROSCOPIA ROTACIONAL - IDENTIFICACIÓN



ESPECTROSCOPIA ROTACIONAL - IDENTIFICACION



Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY
MNRAS 477, 4792–4809 (2018)
Advance Access publication 2018 April 14
doi:10.1093/mnras/sty937

Astrochemical evolution along star formation: overview of the IRAM Large Program ASAI

Bertrand Lefloch,^{1,2} R. Bachiller,³ C. Ceccarelli,¹ J. Cernicharo,⁴ C. Codella,⁵ A. Fuente,³ C. Kahane,¹ A. López-Sepulcre,^{1,6} M. Tafalla,³ C. Vastel,⁷ E. Caux,⁷ M. González-García,^{3,4} E. Bianchi,^{5,8} A. Gómez-Ruiz,^{5,9} J. Holdship,¹⁰ E. Mendoza,² J. Ospina-Zamudio,¹ L. Podio,⁵ D. Quénard,¹⁰ E. Roueff,¹¹ N. Sakai,¹² S. Viti,¹⁰ S. Yamamoto,¹³ K. Yoshida,¹³ C. Favre,⁵ T. Monfredini,¹⁴ H. M. Quitoán-Lara,¹⁴ N. Marcelino,⁴ H. M. Boechat-Roberty¹⁴ and S. Cabrit¹⁵

MNRAS 000, 1–?? (2020) Preprint April 4, 2021 Compiled using MNRAS L^AT_EX style file v3.0

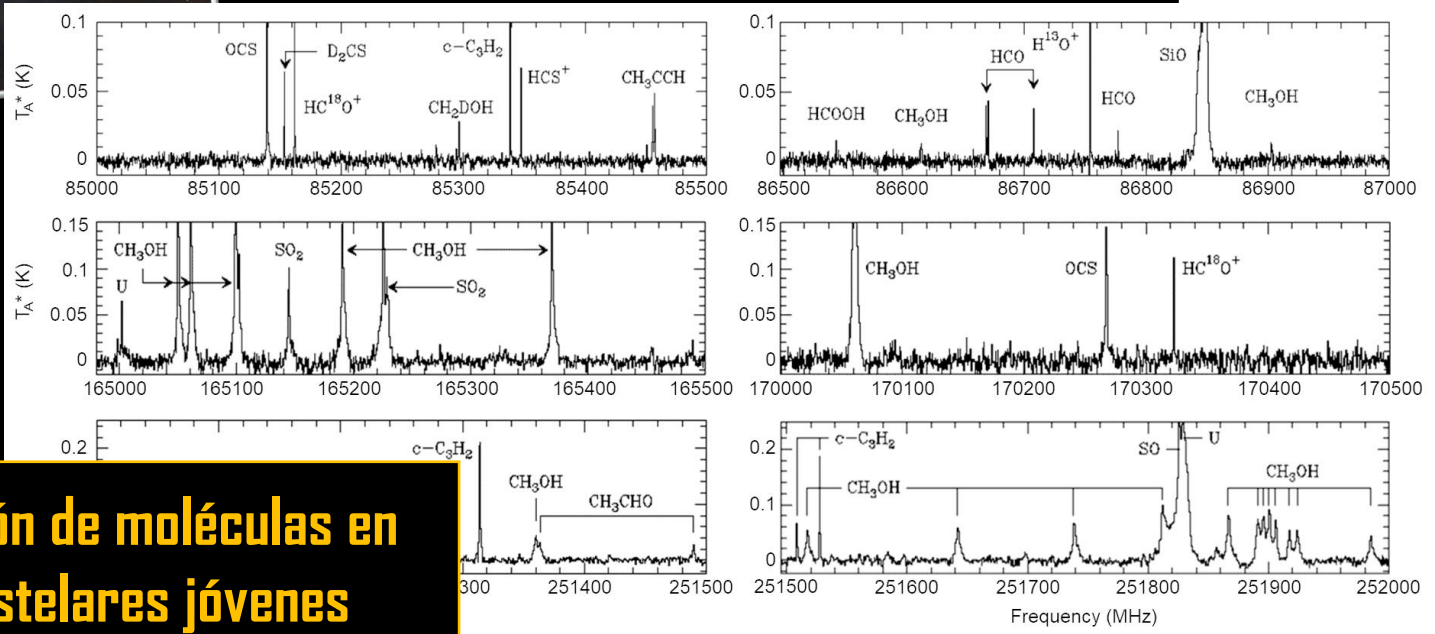
IRAM Large Program ASAI: IRAS 4A millimeter spectral survey

H. M. Quitoán-Lara,¹ B. Lefloch,^{2*} C. Kahane,² and H. M. Boechat-Roberty¹
¹ Observatorio do Valongo, UFRJ, 20080-090 Rio de Janeiro, Brazil
² CNRS, IPAG, Univ. Grenoble Alpes, F-38000 Grenoble, France

Accepted XXX. Received YYY; in original form ZZZ.

ABSTRACT
There is evidence that the molecular complexity observed in small bodies in the solar system such as comets and asteroids has been inherited, at least partially, from the early stages of the formation of the solar system. Therefore, it is important to characterize and understand how the chemical composition and complexity of the region changes along with the protostellar evolution of solar-type objects. In this context, we present here, as part of the Large Program “Astrochemical Surveys At IRAM” (ASAI), the complete spectral study of the bands 3, 2, 1 mm towards the protostellar object of class 0 IRAS 4A. Knowing that unbiased spectral studies are a powerful tool for studying the chemistry and physics of star-forming regions, we present a detailed description of the survey and the results obtained from the analysis of the three-band observations. We present the identification of more than 90 different molecular species, classified as O-, S-, N-bearing and C-chains; separating the main isotopes and rare

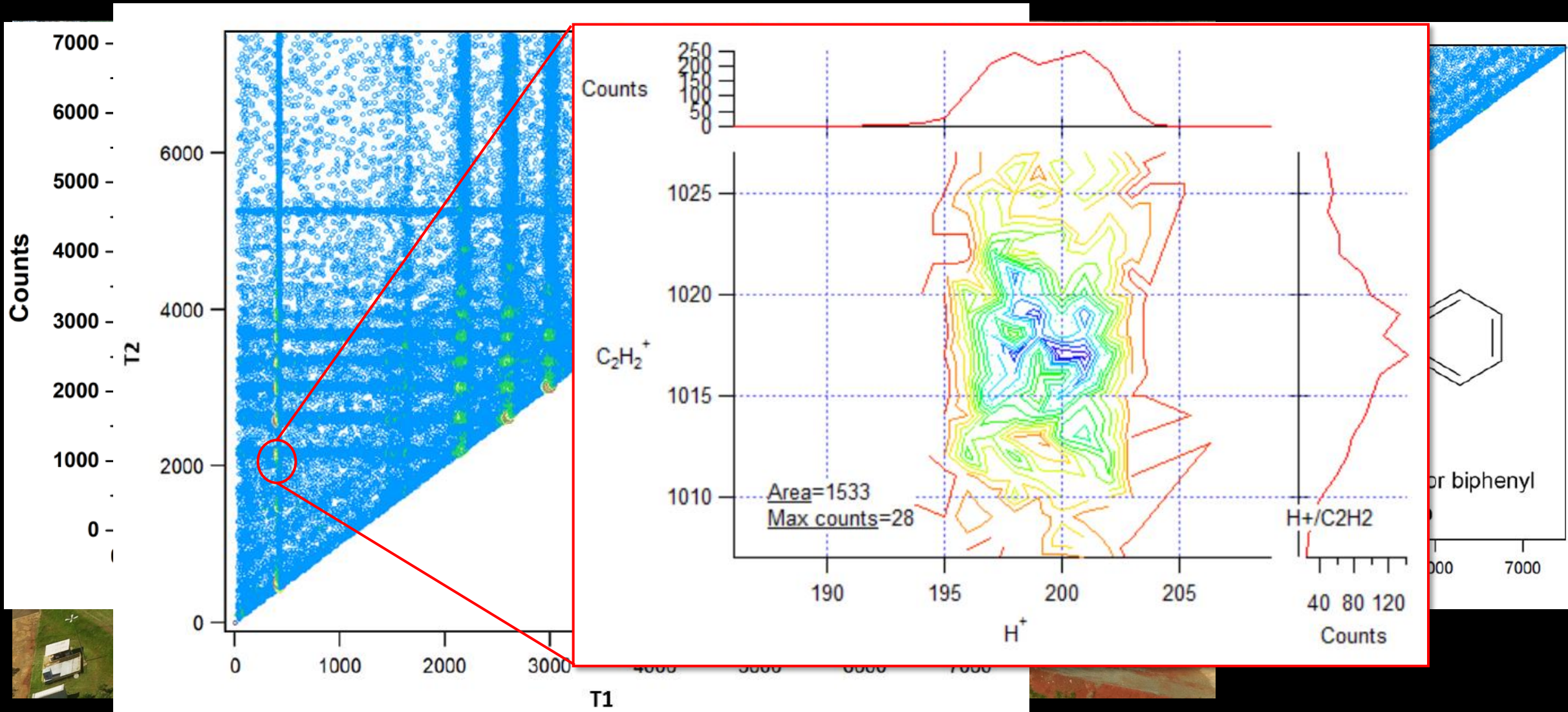
Preparación



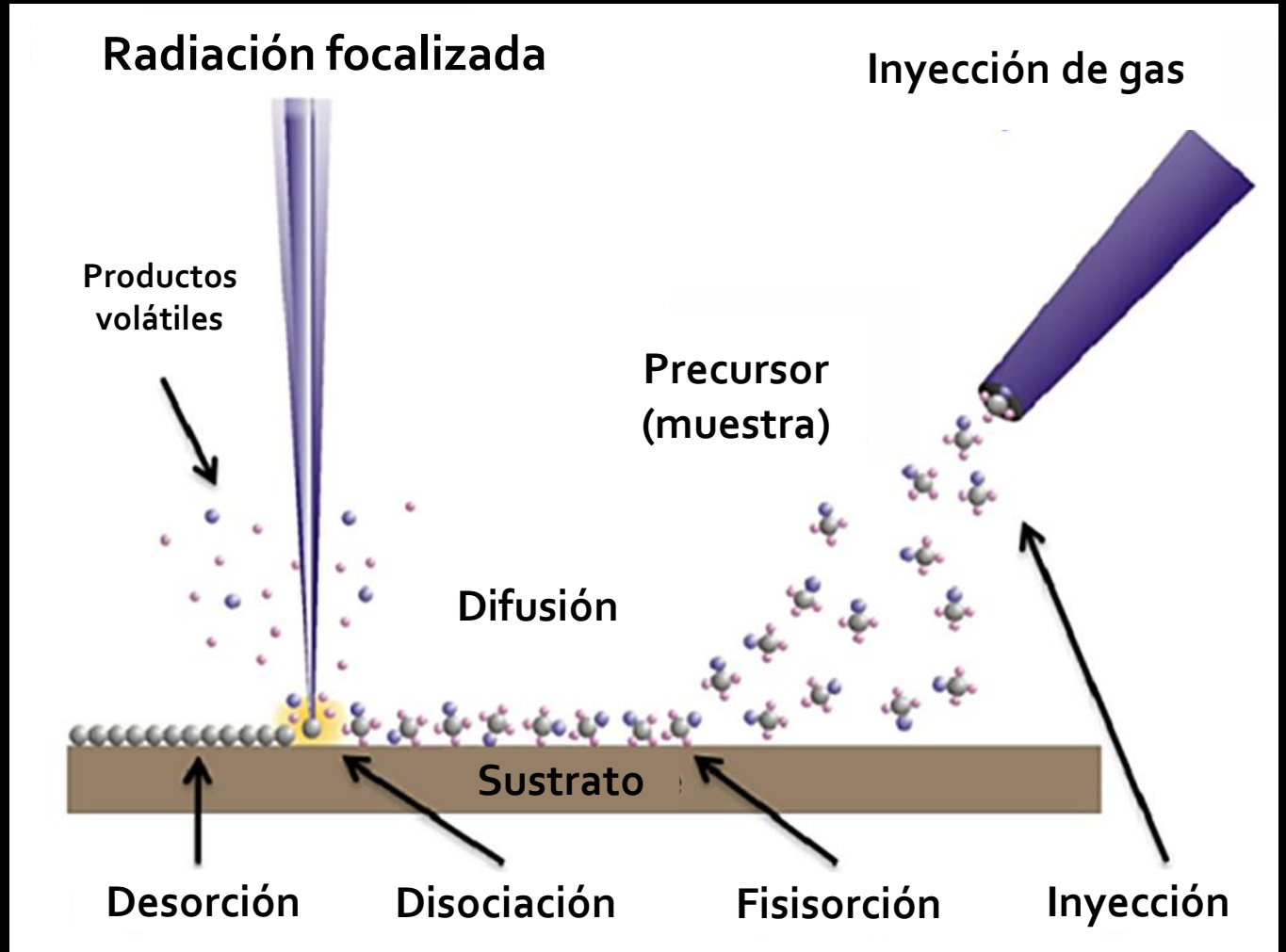
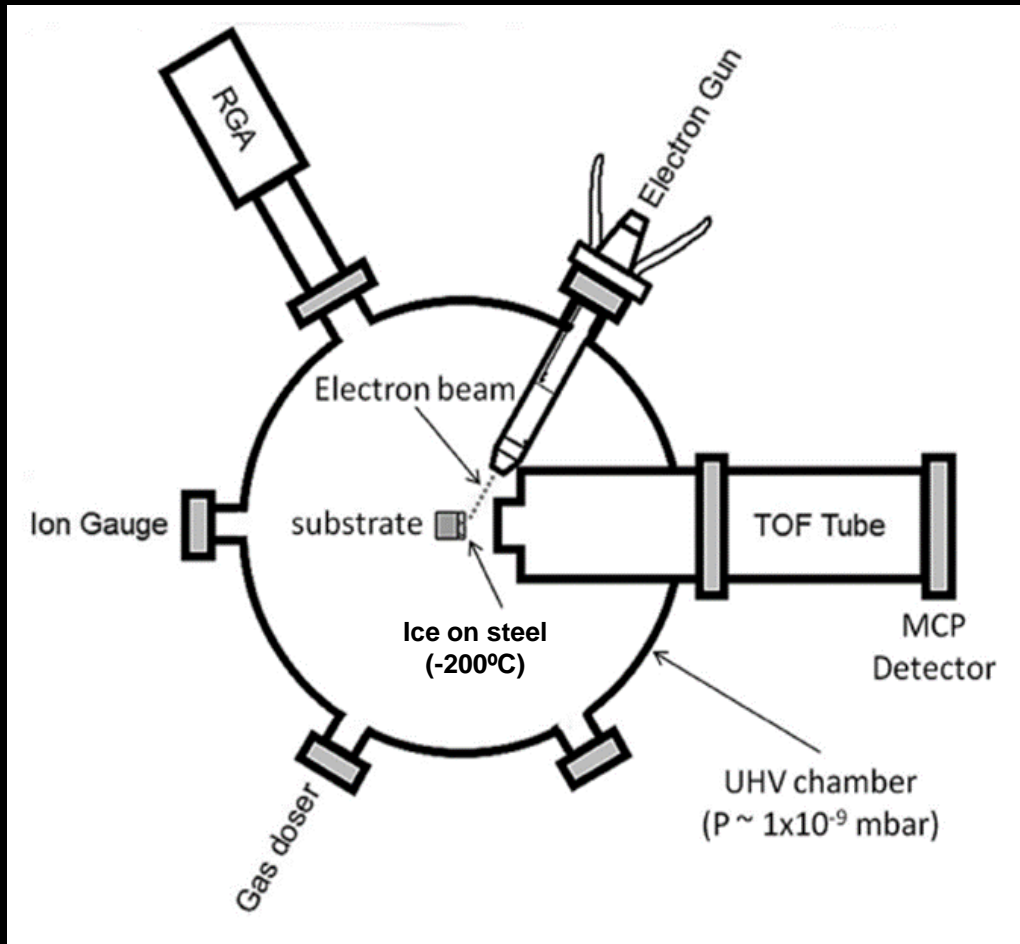
Identificación de moléculas en objetos estelares jóvenes



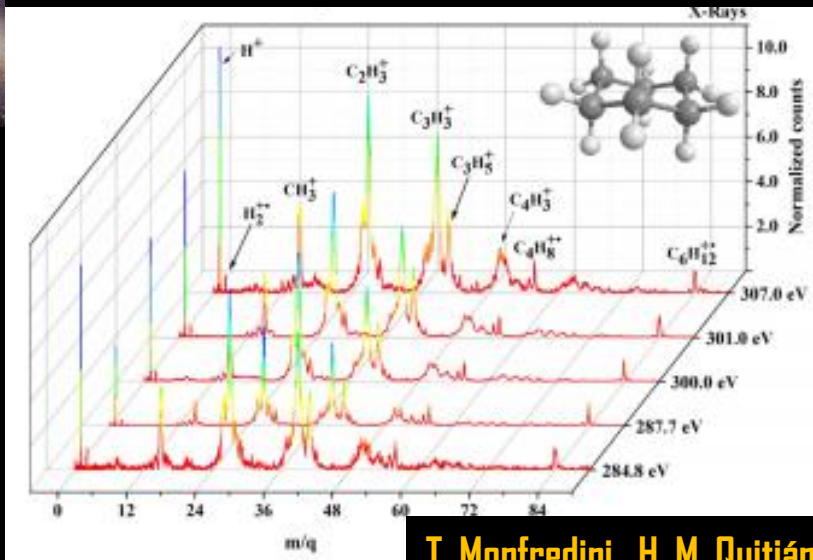
ASTROQUÍMICA EXPERIMENTAL



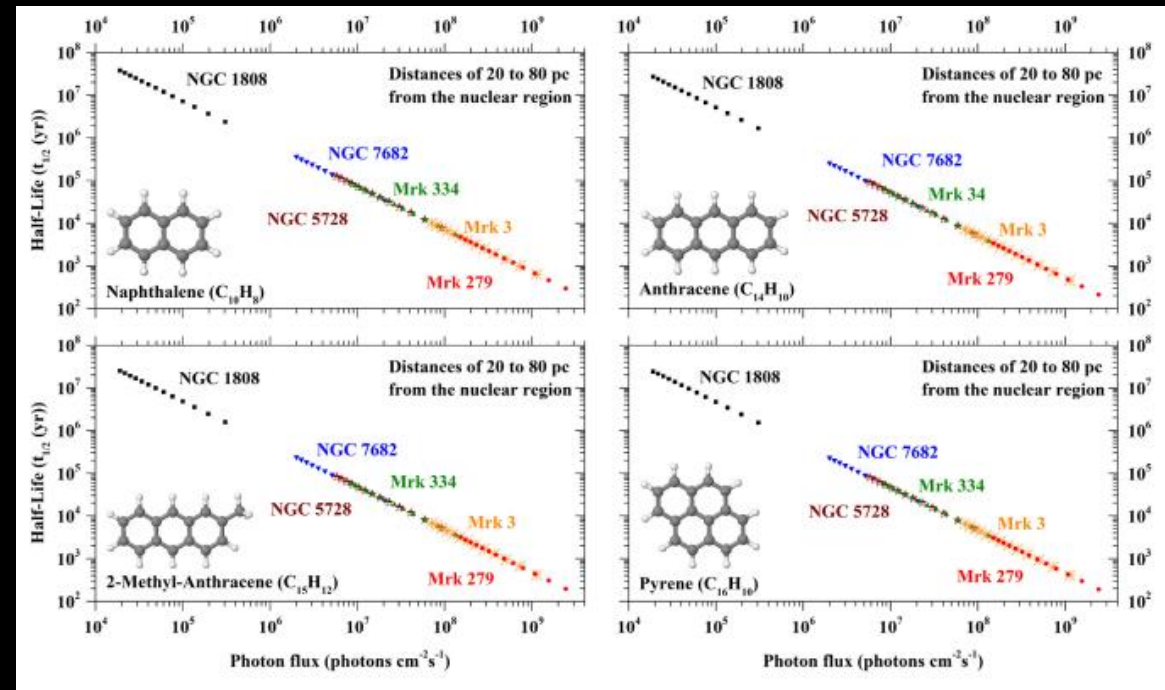
HIELOS ASTROFÍSICOS



Estudios experimentales para determinar tiempos de vida molecular



T. Monfredini, H. M. Quitián-Lara, et al., *MNRAS*, 2019

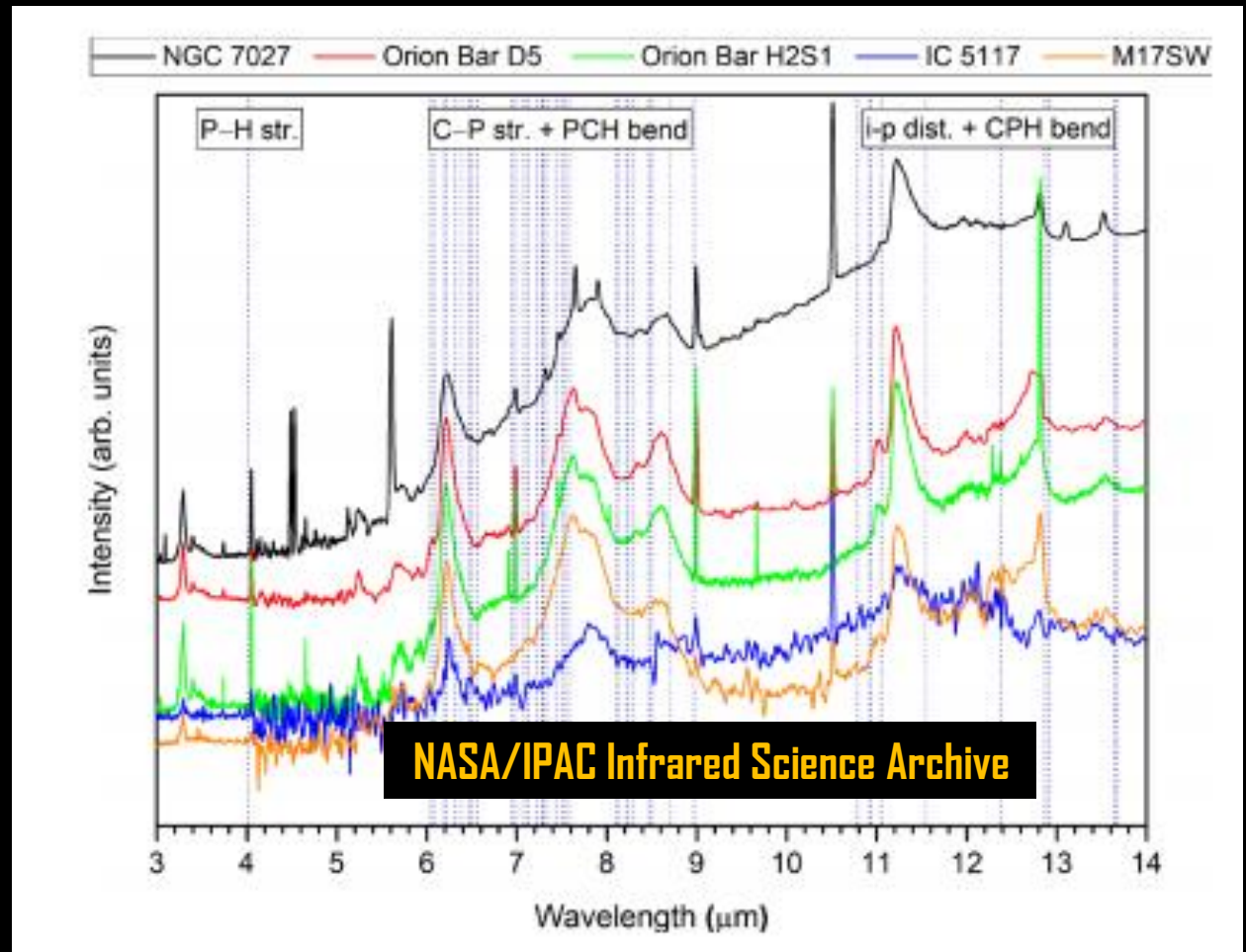


Cálculos espectroscópicos de moléculas de interés astrobiológico

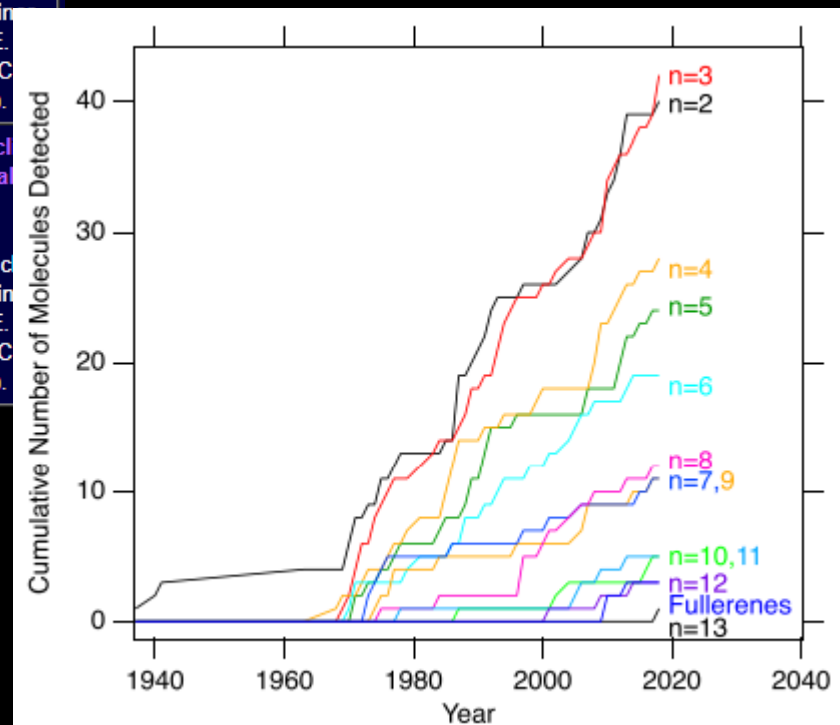
Oliveira, Molpeceres, Fantuzzi, Quitián-Lara, et al., MNRAS, 2021



ESO.org



2021	c-C₅H₅CN cyanocyclopentadiene	Interstellar detection of the highly polar five-membered ring cyanocyclopentadiene M. C. McCarthy, K. L. K. Lee, R. A. Loomis, A. M. Burkhardt, C. N. Shingledecker, S. B. Charnley, M. A. Cordiner, E. Herbst, S. Kalenskii, E. R. Willis, C. Xue, A. J. Remijan, and B. A. McGuire. <i>Nature Astron</i> 5:176-180 (2021).	2021	CH₃CO⁺ acetyl cation	Discovery of the acetyl cation, CH₃CO⁺, in space and in the laboratory J. Cernicharo, C. Cabezas, S. Bailleux, L. Margulès, R. Motiyenko, L. Zou, Y. Endo, C. Bermúdez, M. Agúndez, N. Marcelino, B. Lefloch, B. Tercero, and P. de Vicente. <i>A&A</i> 646:L7 (2021).
2021	HC₁₁N cyanopentaacetylene <i>Astromolecule of the Month</i>	An investigation of spectral line stacking techniques and application to the detection of HC₁₁N R. A. Loomis, A. M. Burkhardt, C. N. Shingledecker, S. B. Charnley, M. A. Cordiner, E. Herbst, S. Kalenskii, K. L. K. Lee, E. R. Willis, C. Xue, A. J. Remijan, M. C. McCarthy, and B. A. McGuire. <i>Nature Astron</i> 5, 188-196 (2021).	2021	C₅H₅CN 2-cyanocyclopentadiene	Interstellar Detection of 2-cyanocyclopentadiene, C₅H₅CN, a Second Five-membered Ring toward TMC-1 K. L. K. Lee, P. B. Changala, R. A. Loomis, A. M. Burkhardt, C. Xue, M. A. Cordiner, S. B. Charnley, M. C. McCarthy, and B. A. McGuire. <i>ApJL</i> 910:L2 (2021).
2021	HC≡CCH=CHC≡N trans-cyanovinylacetylene	Discovery of Interstellar trans-cyanovinylacetylene (HC≡CCH=CHC≡N) and vinylcyanoacetylene (H₂C=CHC₃N) in GOTHAM Observations of TMC-1 K. L. K. Lee, R. A. Loomis, A. M. Burkhardt, I. R. Cooke, C. Xue, M. A. Siebert, C. N. Shingledecker, A. Remijan, S. B. Charnley, M. C. McCarthy, and B. A. McGuire. <i>ApJL</i> 908:L11 (2021).	2021	C₁₀H₇CN 1-cyanonaphthalene	Detection of two interstellar polycyclic aromatic hydrocarbons via spectral matched filtering B. A. McGuire, R. A. Loomis, A. M. Burkhardt, K. L. K. Lee, C. N. Shingledecker, S. B. Charnley, I. R. Cooke, M. A. Cordiner, E. Herbst, S. Kalenskii, M. A. Siebert, E. Willis, C. Xue, A. J. Remijan, and M. C. McCarthy. <i>Science</i> 371:1265 (2021).
2021	H₂C=CHC₃N vinylcyanoacetylene	Discovery of Interstellar trans-cyanovinylacetylene (HC≡CCH=CHC≡N) and vinylcyanoacetylene (H₂C=CHC₃N) in GOTHAM Observations of TMC-1 K. L. K. Lee, R. A. Loomis, A. M. Burkhardt, I. R. Cooke, C. Xue, M. A. Siebert, C. N. Shingledecker, A. Remijan, S. B. Charnley, M. C. McCarthy, and B. A. McGuire. <i>ApJL</i> 908:L11 (2021).	2021	C₁₀H₇CN 2-cyanonaphthalene	Detection of two interstellar polycyclic aromatic hydrocarbons via spectral matched filtering B. A. McGuire, R. A. Loomis, A. M. Burkhardt, K. L. K. Lee, C. N. Shingledecker, S. B. Charnley, I. R. Cooke, M. A. Cordiner, E. Herbst, S. Kalenskii, M. A. Siebert, E. Willis, C. Xue, A. J. Remijan, and M. C. McCarthy. <i>Science</i> 371:1265 (2021).
2021	HC₃S⁺ protonated C ₃ S	Space and laboratory discovery of HC₃S⁺ J. Cernicharo, C. Cabezas, Y. Endo, N. Marcelino, M. Agúndez, B. Tercero, J. D. Gallego, and P. de Vicente. <i>A&A</i> 646:L3 (2021).			



<http://www.astrochymist.org/>

A. McGuire, *ApJ*, 239, 2018



Internship en Astrofísica RECA

Sobre el programa

El Internship en Astrofísica RECA es un programa de formación en investigación científica en Astronomía, Astrofísica y Cosmología dirigido a estudiantes de instituciones colombianas. Durante un periodo de aproximadamente 10 semanas, los estudiantes desarrollarán un proyecto de investigación supervisado por científicos dentro y fuera del país. De esta manera, pretendemos fomentar en el estudiante las capacidades necesarias para realizar investigación científica, contribuir con su formación académica y mejorar su currículum en aras de fortalecer aplicaciones a programas de posgrado en astronomía y áreas afines a nivel global.



Solicitud de participación de estudiantes para el 2021:

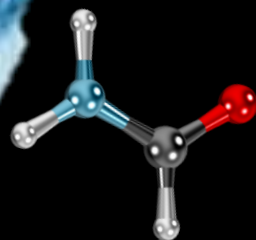
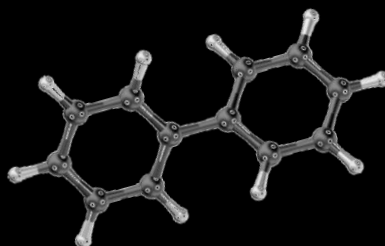
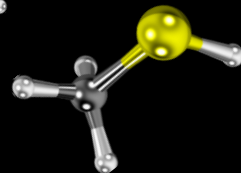
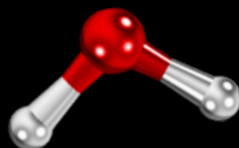
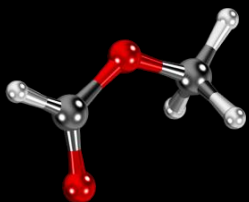
La convocatoria para participar en el internship del 2021 esta abierta hasta el 30 de abril. Para este año tendremos 12 proyectos de investigación por lo que se aceptaran 12 estudiantes. La selección de estudiantes se basará en una carta de motivación, CV, notas, además de los requisitos descritos abajo. Para hacer parte del programa por favor llenar este formulario de postulación.

Requisitos:

- Estar en los últimos dos años del pregrado o licenciatura en física, astronomía o áreas afines.
- Si la o el estudiante ya terminó el pregrado y no ha empezado una maestría es elegible para aplicar.
- Estar en los últimos dos años del pregrado o licenciatura en física, astronomía o áreas afines.
- La o el estudiante debe residir en Colombia.
- Tener disponibilidad de tiempo para realizar el proyecto de investigación durante los meses de Mayo y Agosto.

<https://recastronomia.github.io/internship/>

Gracias!



Contacto: heidy.quitian-lara@uni-wuerzburg.de

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- Astronomía
- Astrofísica
- Cosmología

INTERNSHIP RECA

INSCRIPCIONES GRATIS EN:

Para más
información sobre
el programa:



Fecha límite para
la aplicación:
Viernes 30 de Abril.

