Espectroscopía de microchorros: gases y líquidos fuera del equilibrio

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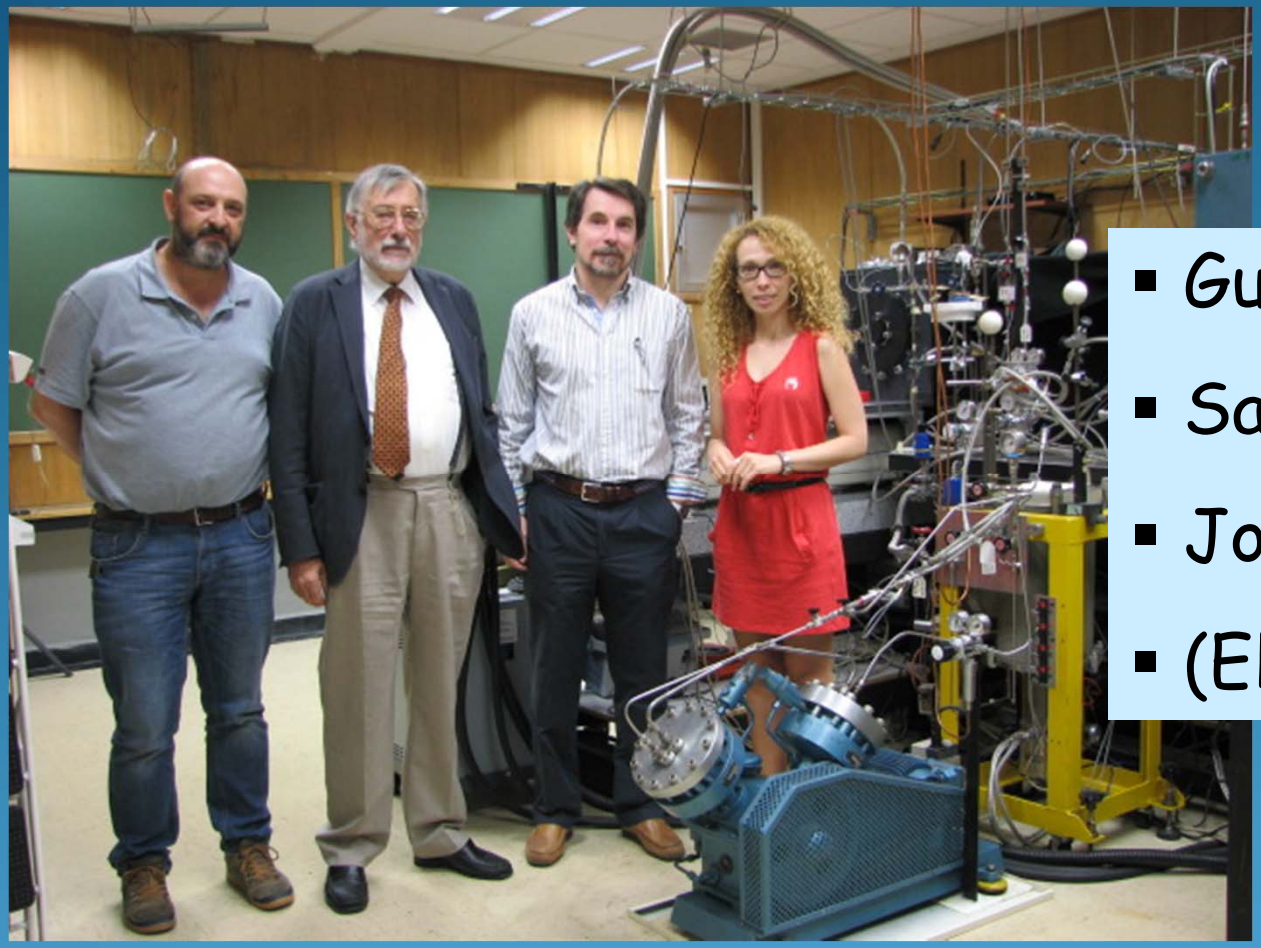
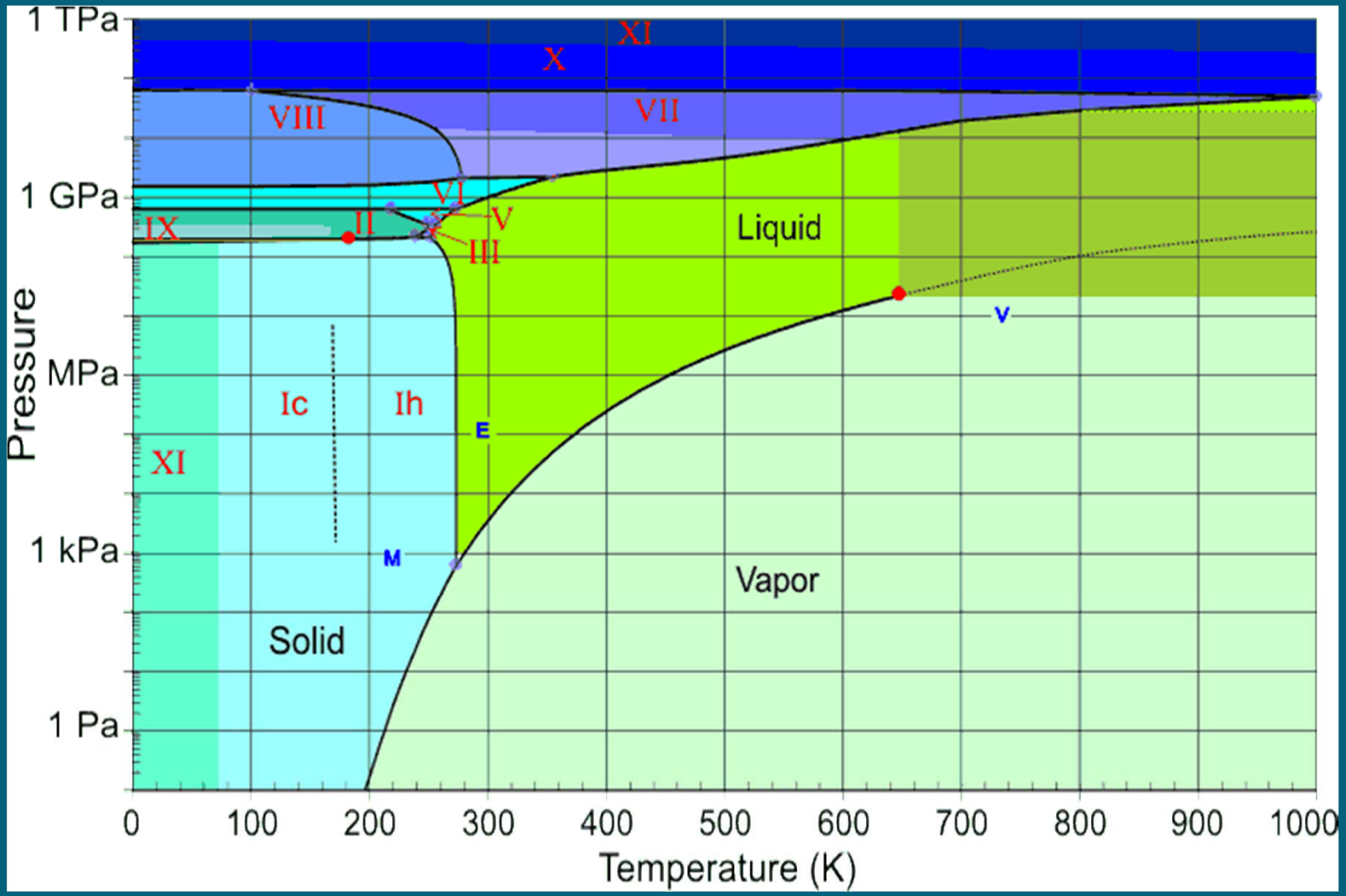


- Guzmán Tejeda
- Salvador Montero
- José Mª Fernández
- (Elena Moreno)

http://www.iem.csic.es/fismol/fdm/

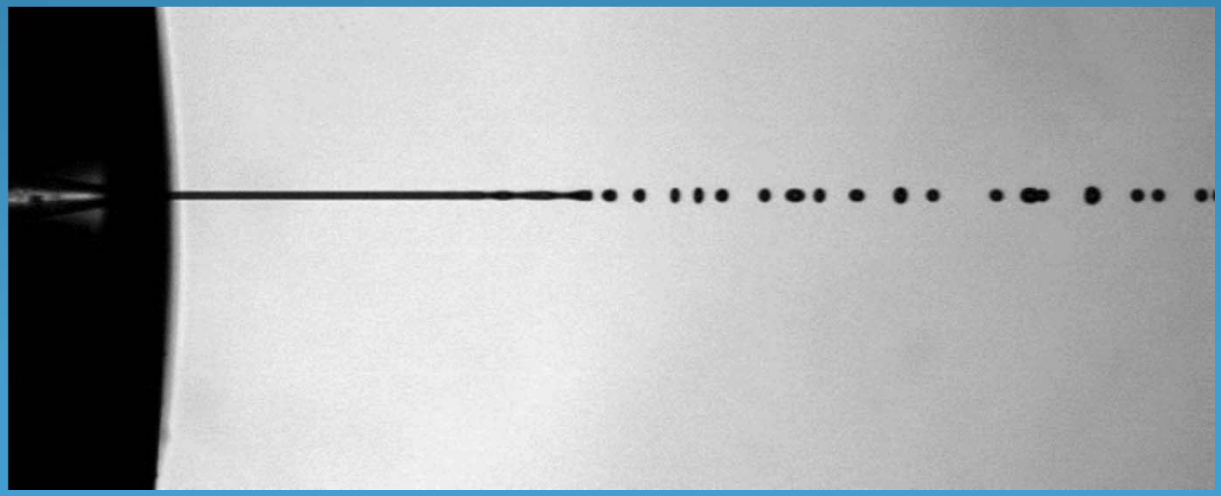
Phase diagram (equillibrium)



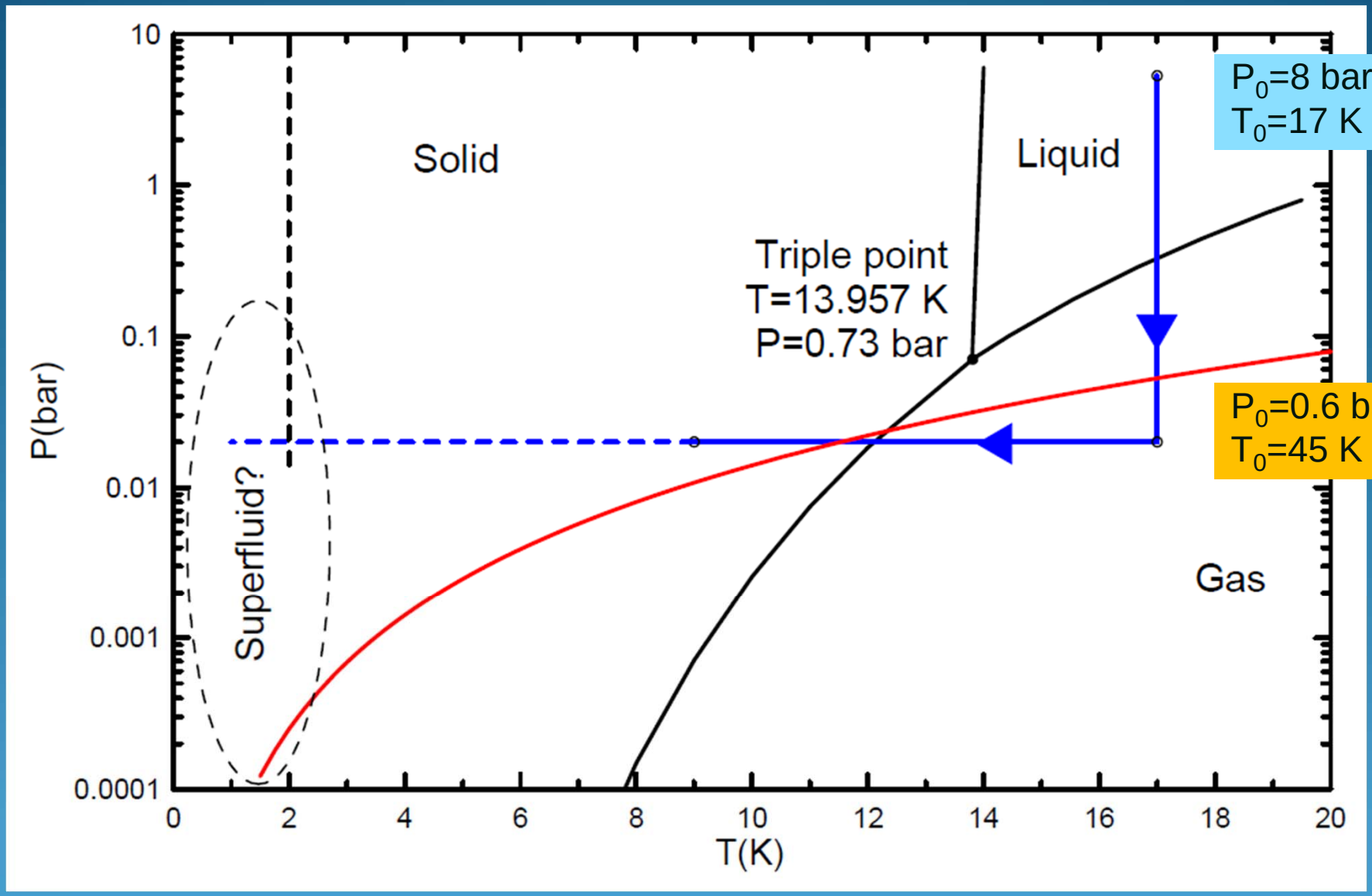
M. Chaplin, Water Structure and Science , http://www1.lsbu.ac.uk/water/

Microchorros líquidos subenfriados

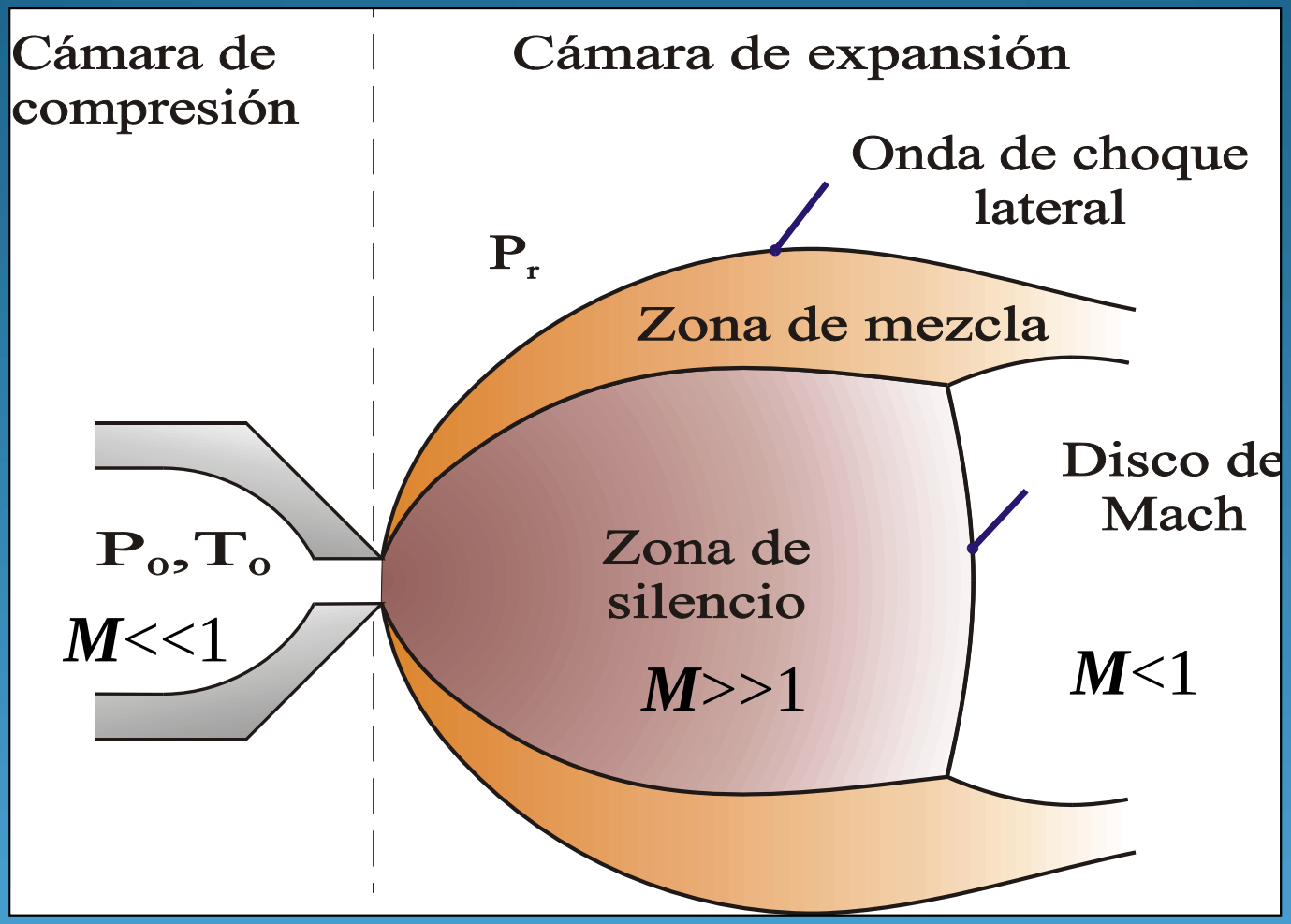
- Tobera < 10 micras
- Líquido presurizado (5-20 bar)
- Se enfrían por evaporación superficial (en vacío)
- Densidad ~ constante
- Fluctuaciones de Rayleigh: rotura en gotas -> líquido



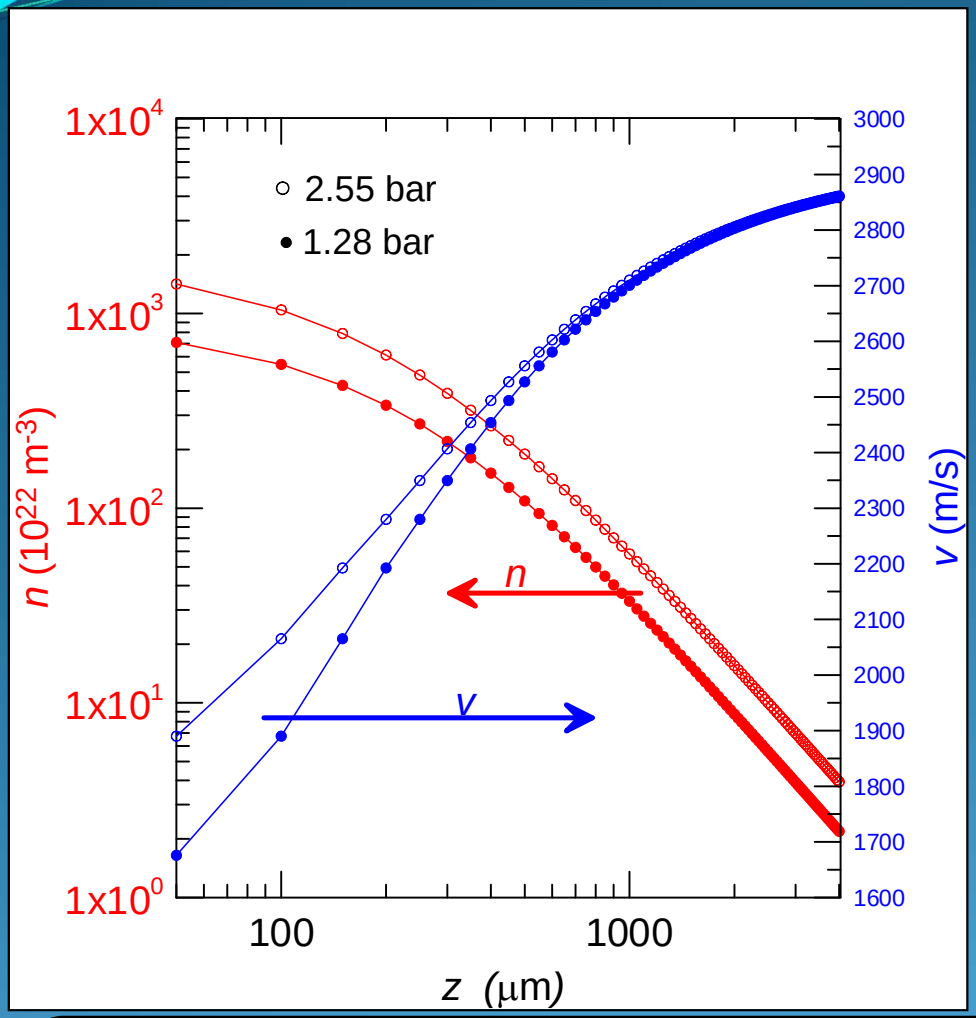
Trayectorias en el diagrama de fases H_2

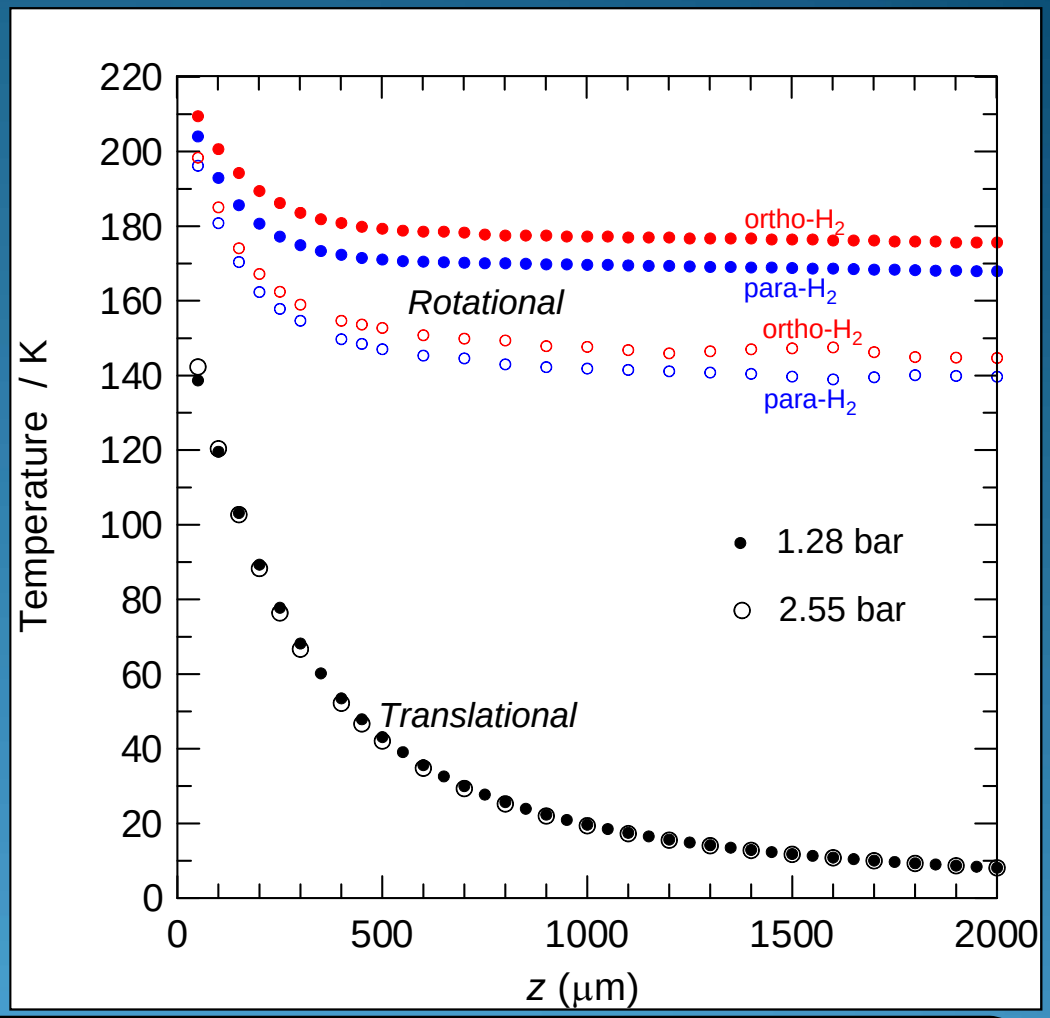


Chorros supersónicos de gases. Generalidades



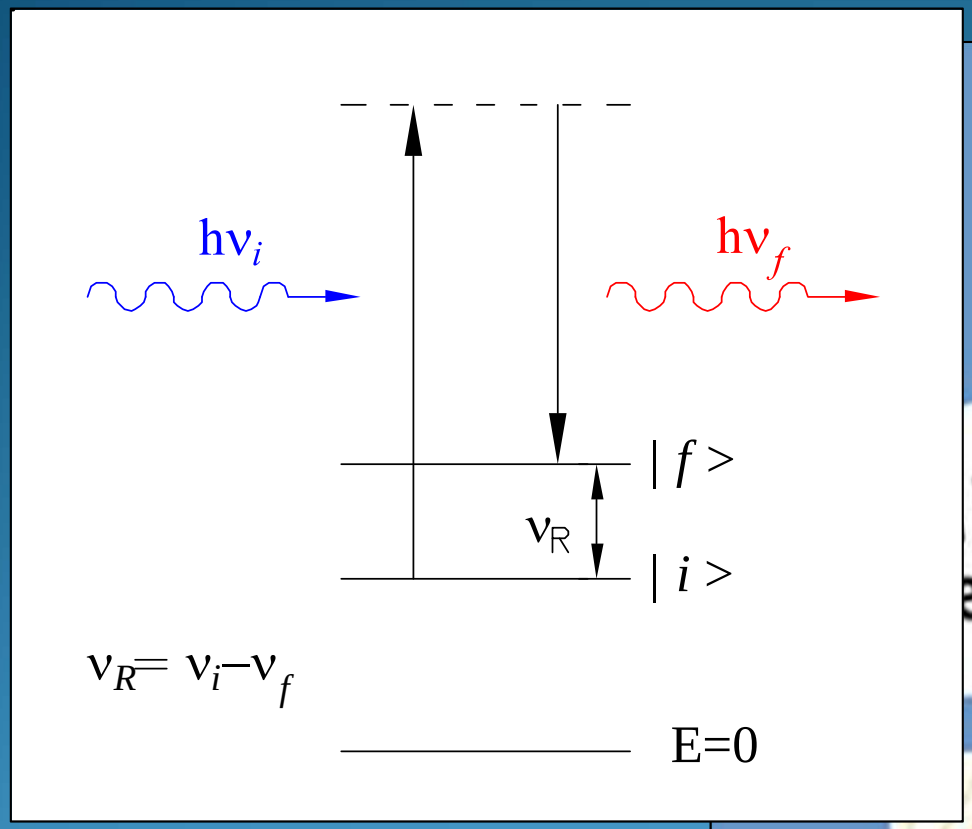
Chorros supersónicos. Zona de silencio

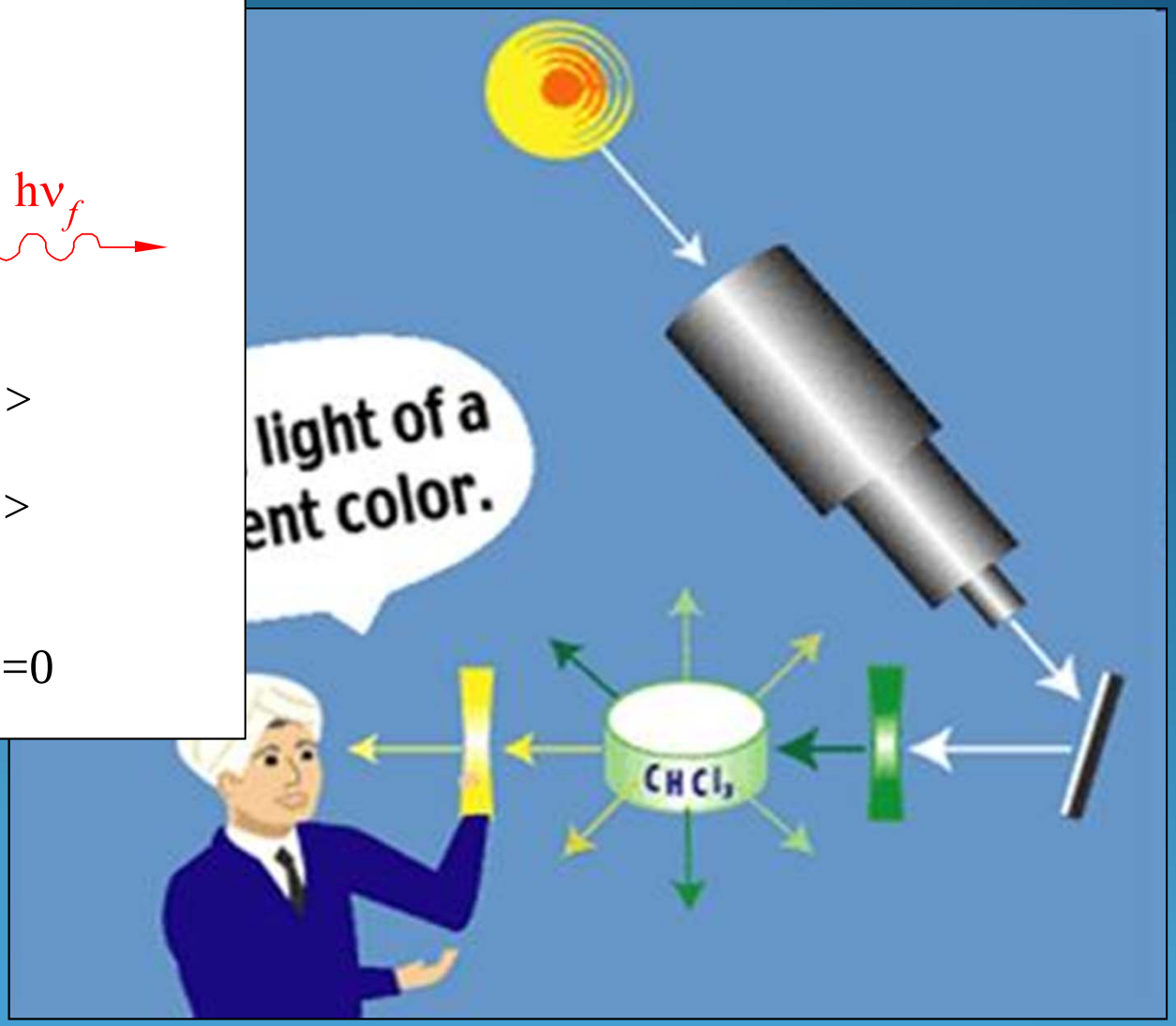




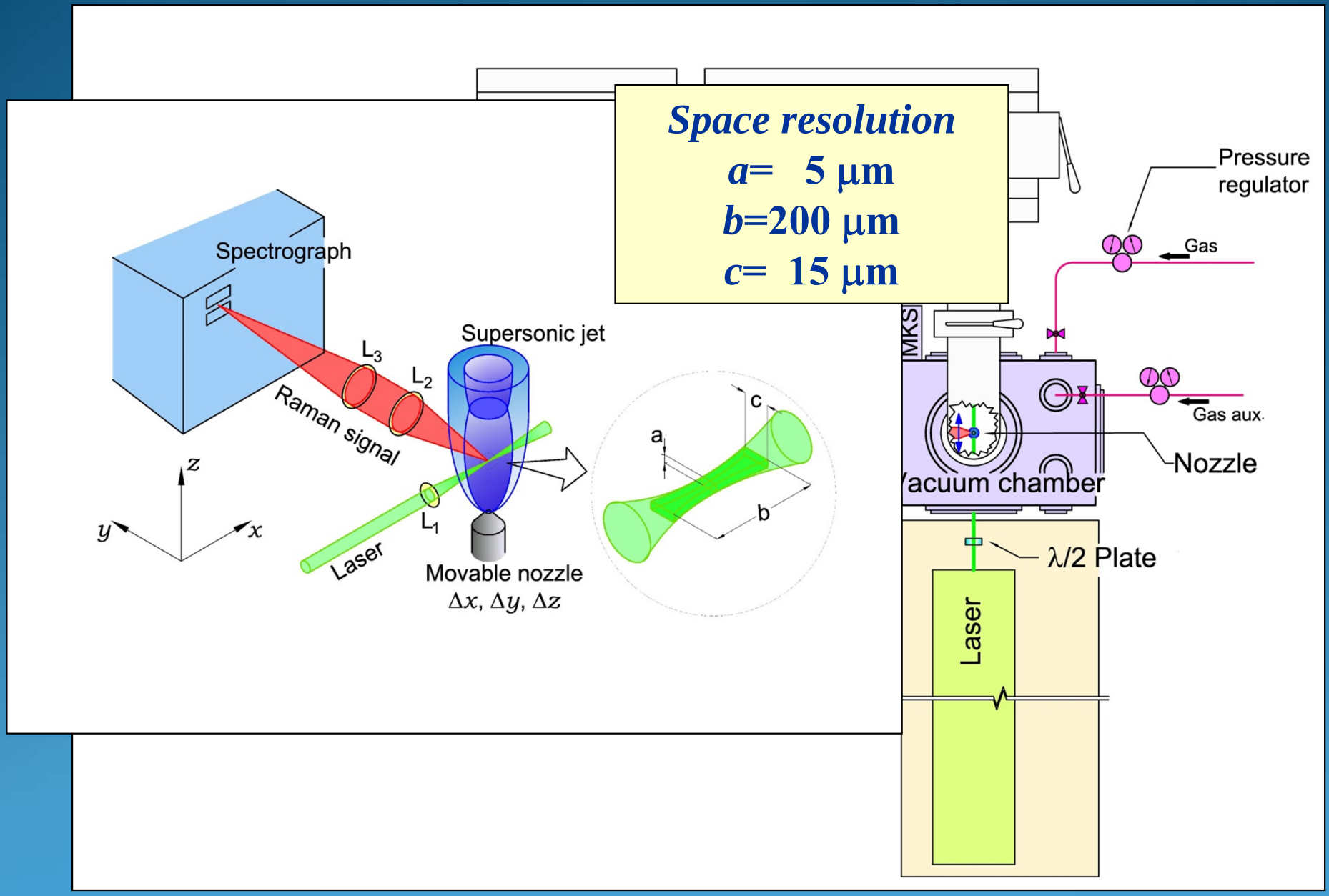
- Se rompe el equilibrio TD: Ttras ≠Trot ≠ Tvib
- El chorro supersónico es un sistema dinámico, condicionado por la cinética de colisiones: congelación Trot

Efecto Raman: Scattering inelástico de luz





Montaje experimental



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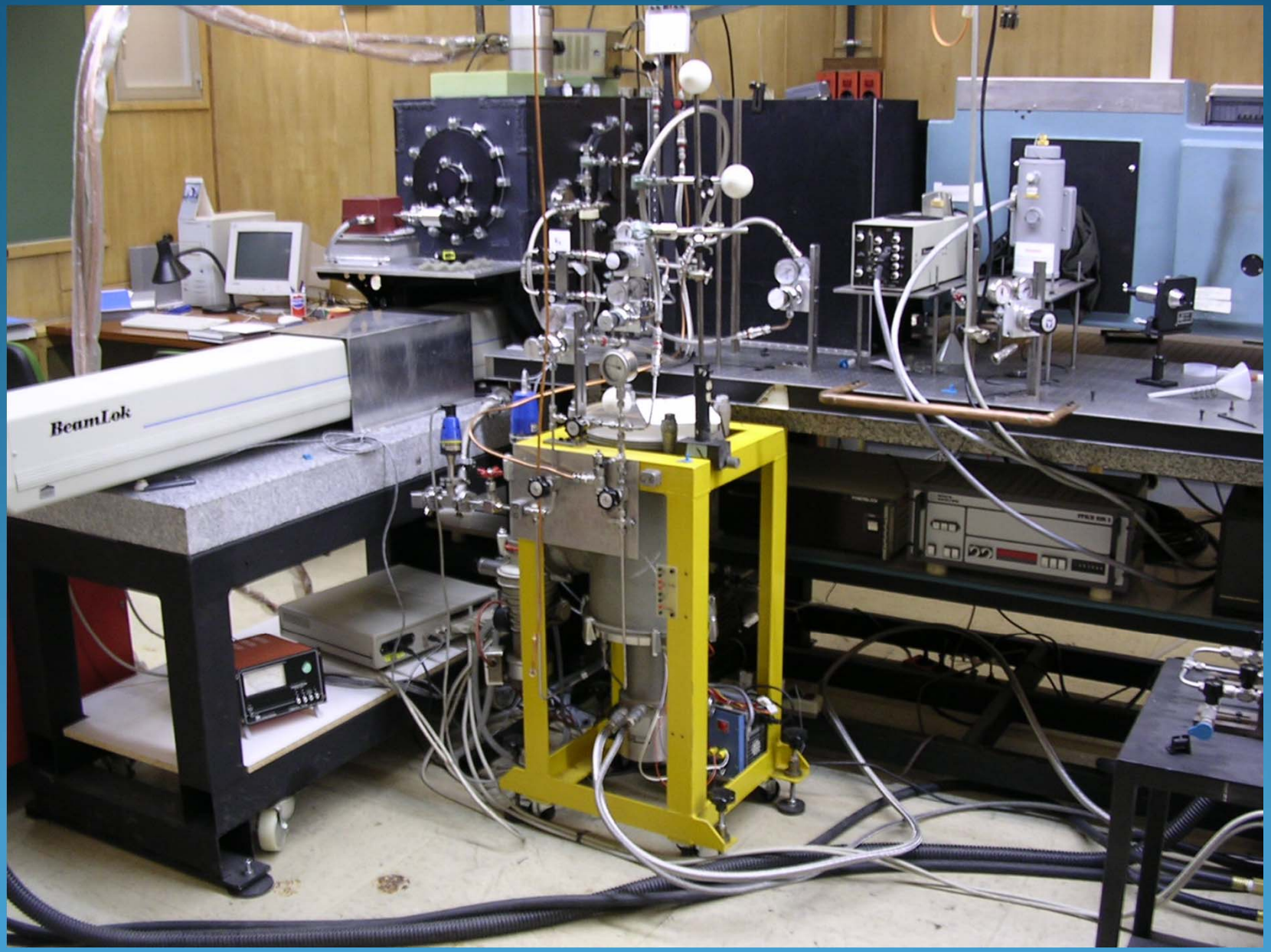
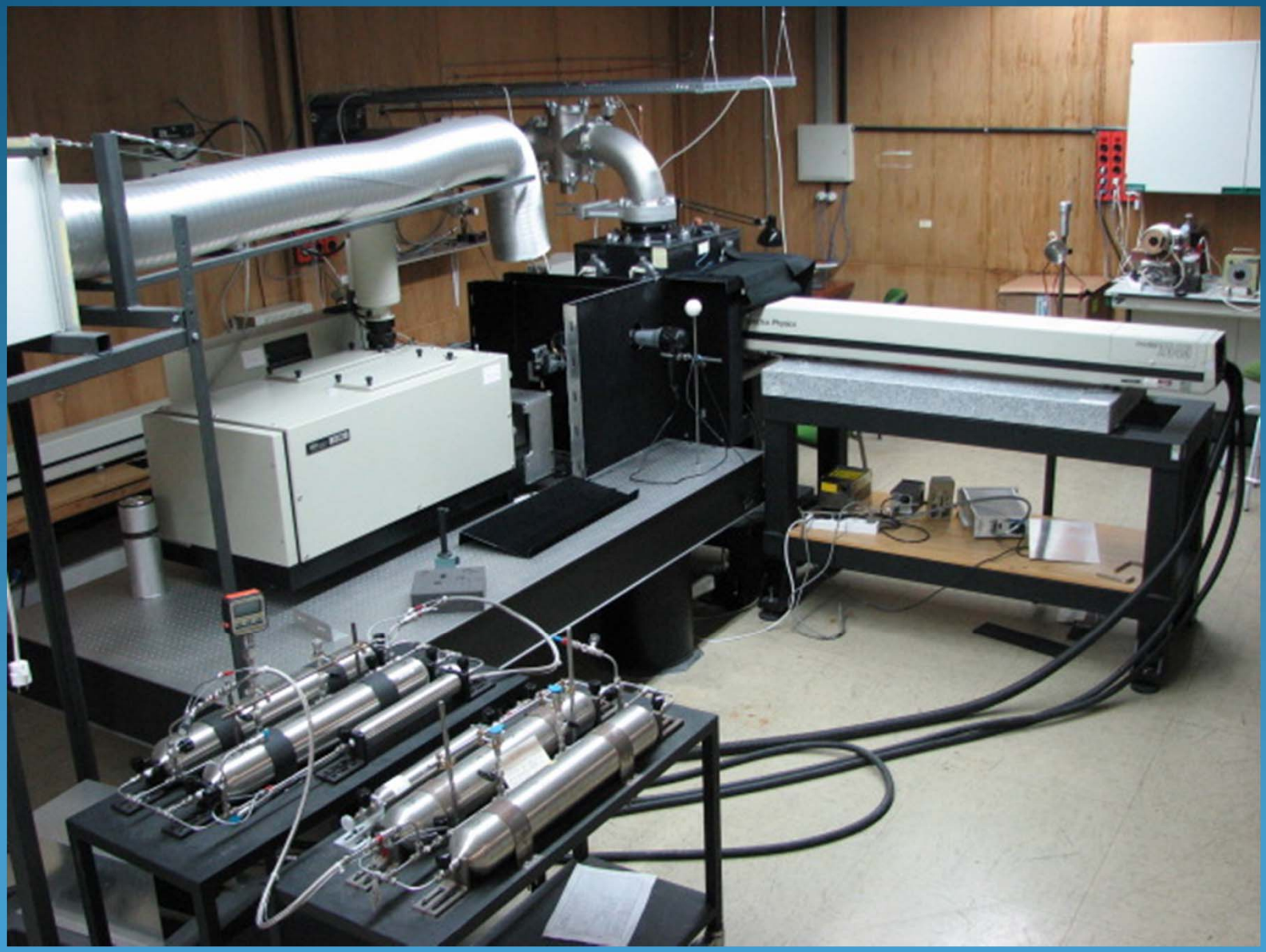
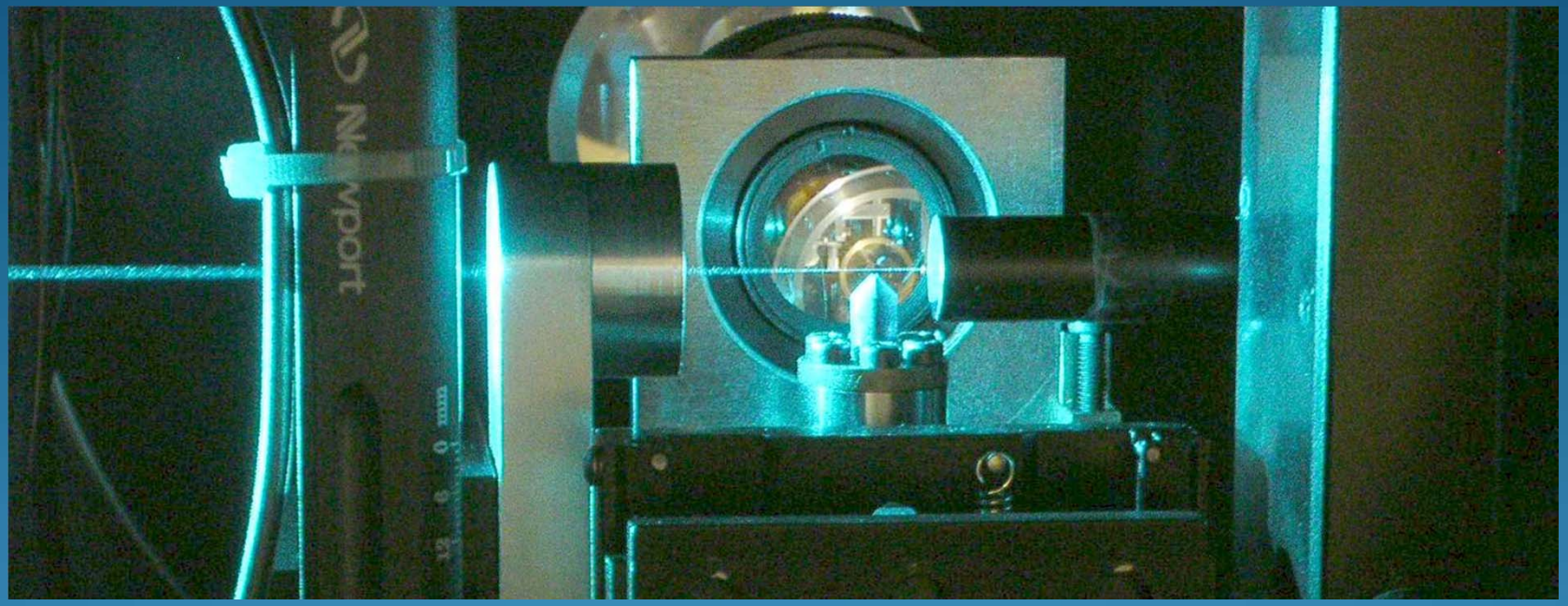


Montaje experimental



Montaje experimental

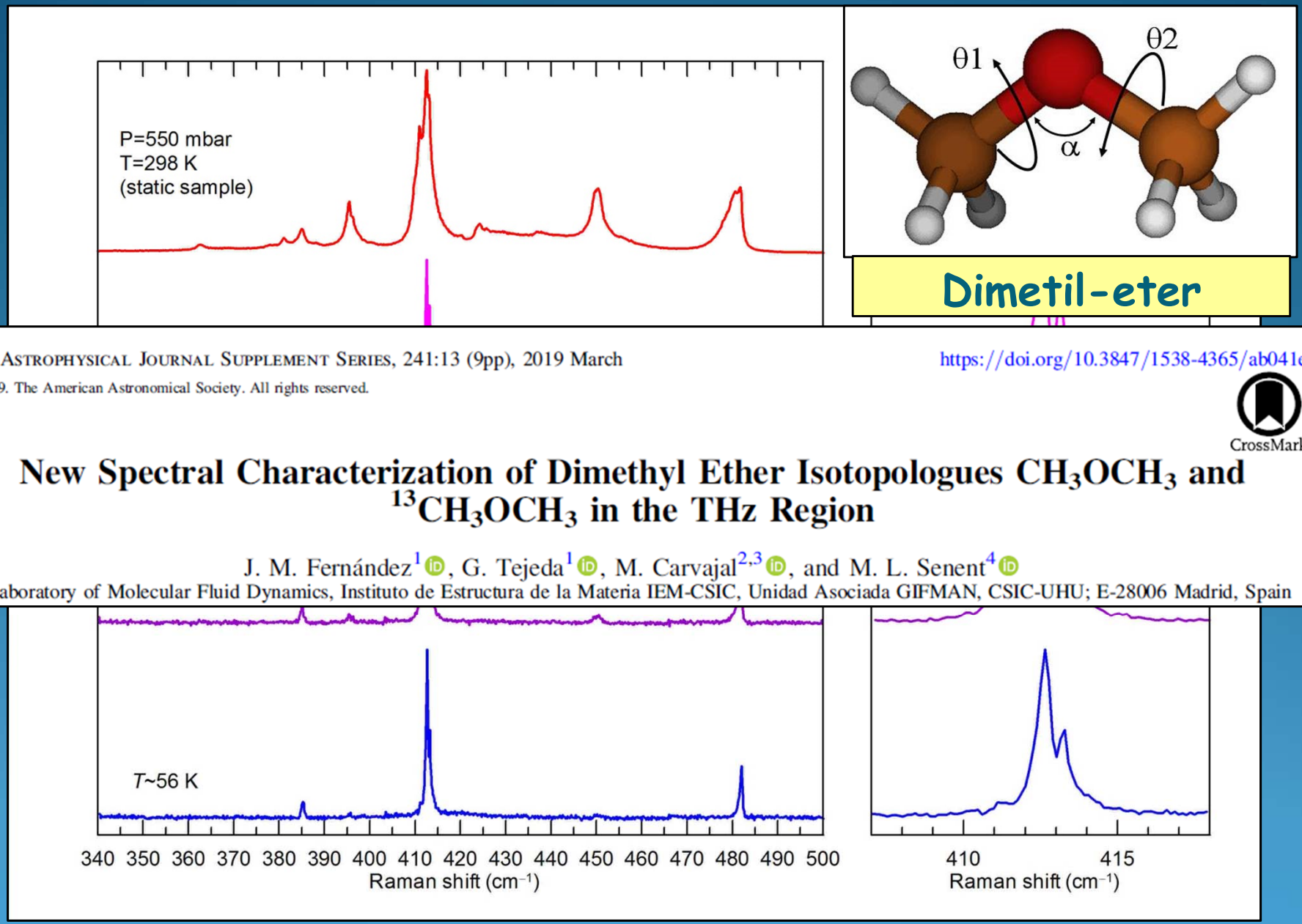


- Movemos la tobera para muestrear el chorro
- Resolución espacial: 1 μm
- Resolución temporal:
  - Gas: v ~ 1000 m/s => 1 ns
  - Líquido v ~ 100 m/s.=> 10 ns

¿Qué podemos estudiar con espectroscopía Raman en chorros de fluidos?

- espectros de moléculas frías
- espectros de moléculas calientes
- mapas de temperaturas en chorros de gases
- mapas de densidades en chorros de gases
- colisiones moleculares inelásticas
- agregación molecular
- solidificación de líquidos subenfriados

Espectroscopía Raman a baja temperatura



Dimetil-eter

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 241:13 (9pp), 2019 March
https://doi.org/10.3847/1538-4365/ab041e

New Spectral Characterization of Dimethyl Ether Isotopologues CH_3OCH_3 and $^{13}CH_3OCH_3$ in the THz Region

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Colisiones inelásticas H_2O:He

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 216:3 (8pp), 2015 January doi:10.1088/0067-0049/216/1/3

LABORATORY STUDY OF RATE COEFFICIENTS FOR H_2O:He INELASTIC COLLISIONS BETWEEN 20 AND 120 K

G. TEJEDA[1], E. CARMONA-NOVILLO[2], E. MORENO[1], J. M. FERNÁNDEZ[1], M. I. HERNÁNDEZ[2], AND S. MONTERO[1]
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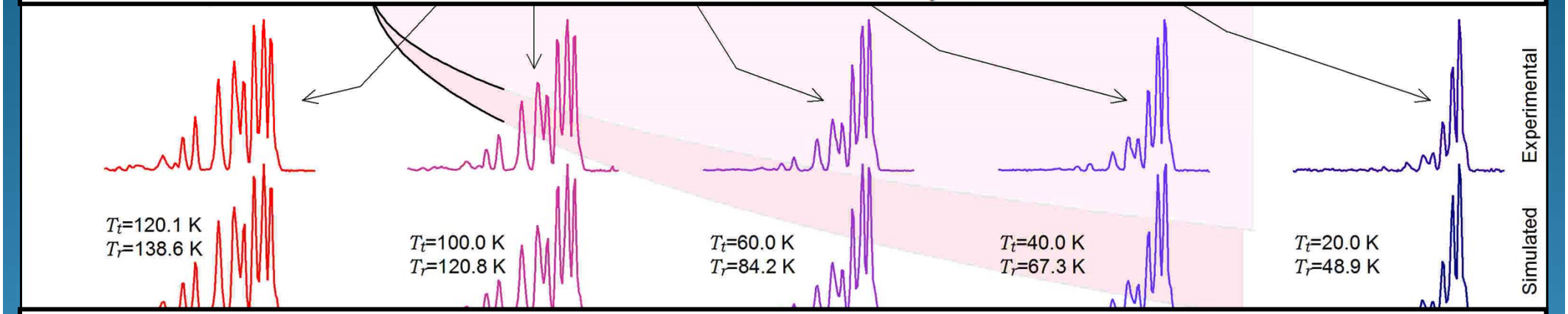

THE ASTROPHYSICAL JOURNAL, 808:175 (7pp), 2015 August 1 doi:10.1088/0004-637X/808/2/175

BROADENING OF H_2O ROTATIONAL LINES BY COLLISIONS WITH He ATOMS AT LOW TEMPERATURE

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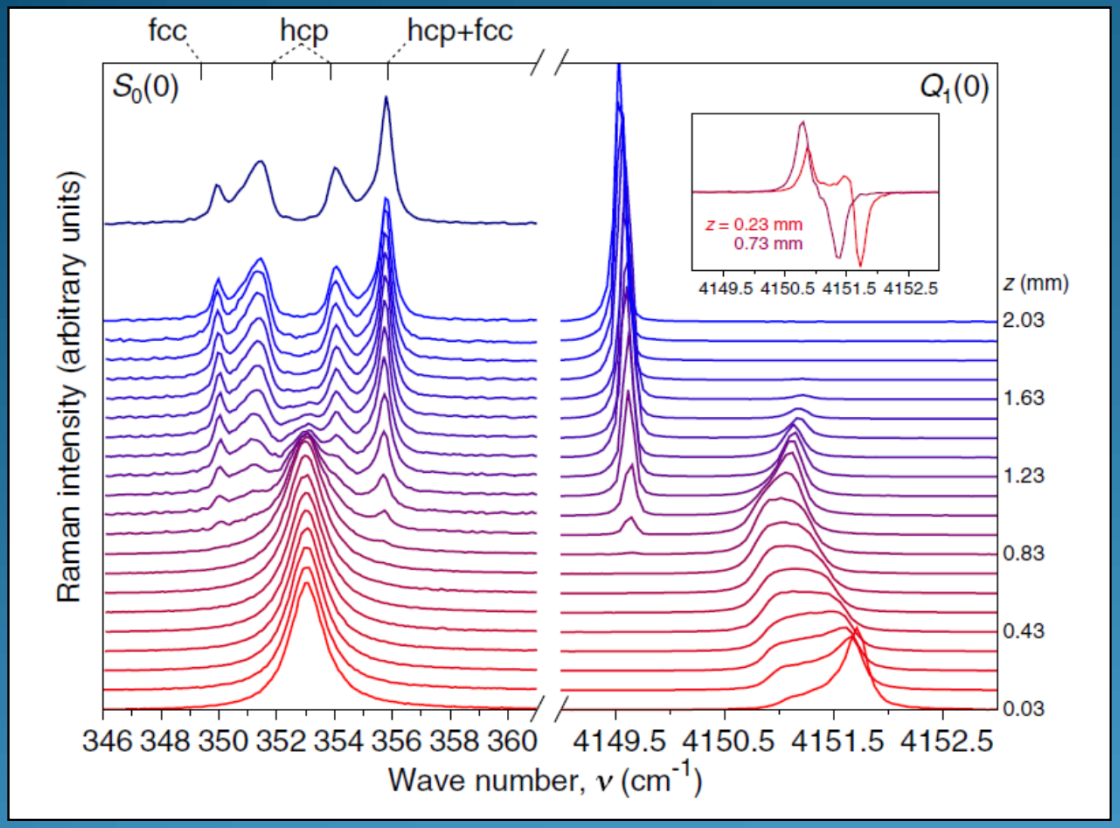
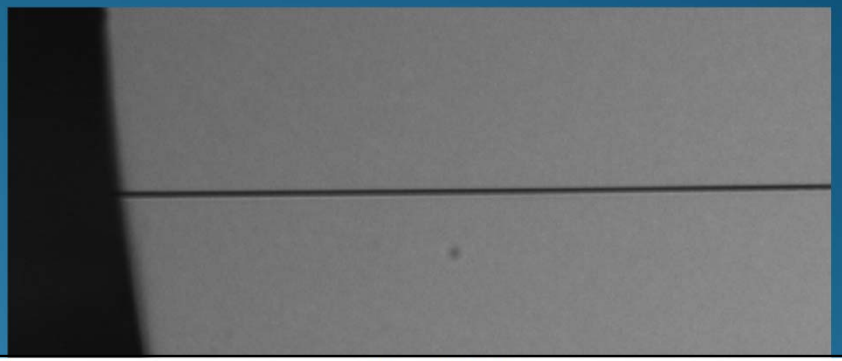
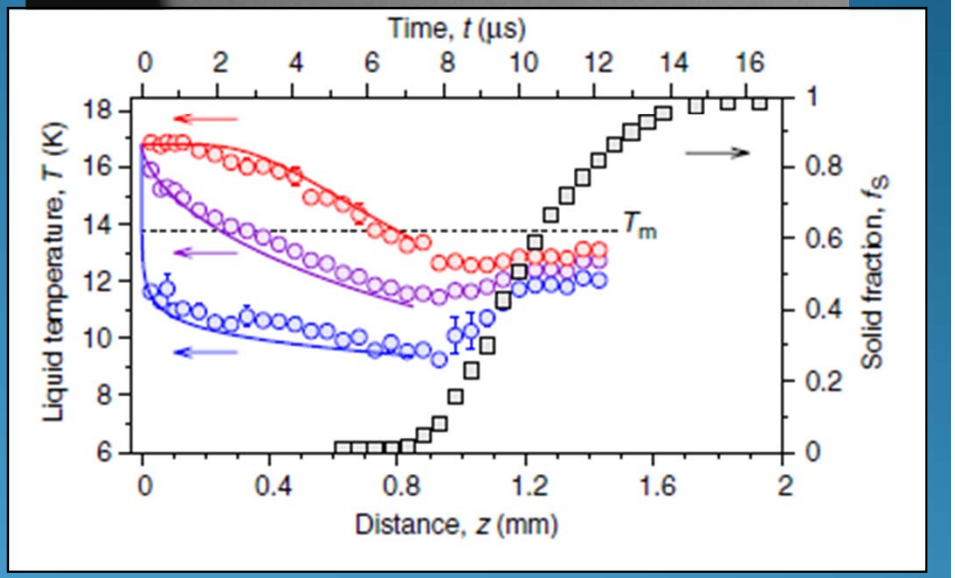
Microchorros de *para*-H_2 y *orto*-D_2 líquidos





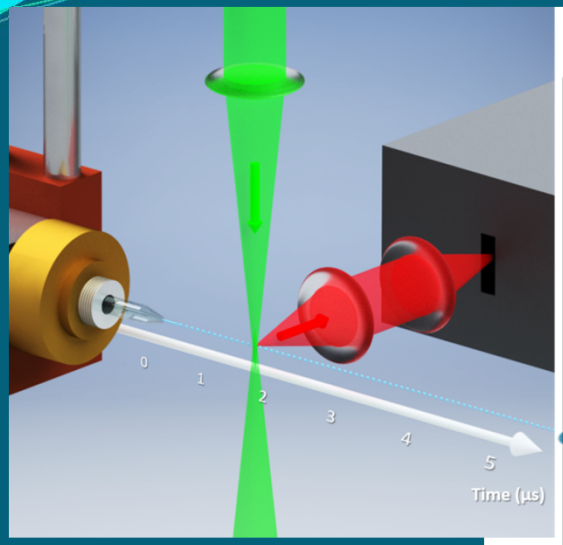


Kühnel, Fernández, Tejeda, Kalinin, Montero, Grisenti, Phys. Rev. Lett. **106**, 245301 (2011)

Kühnel, Fernández, Tramonto, Tejeda, Moreno, et al., Phys. Rev. B **89**, 180201(R) (2014)

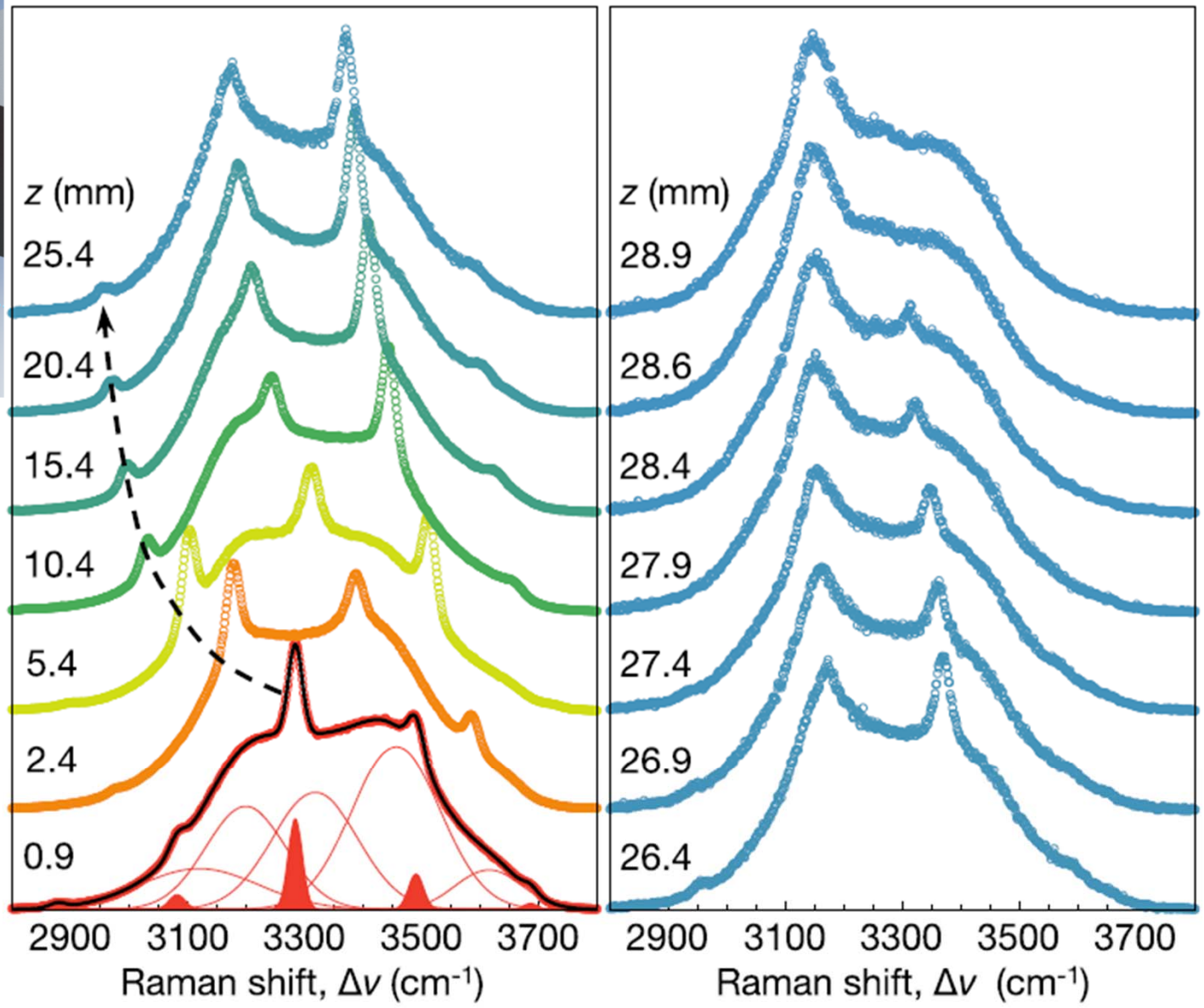
Kühnel, Fernández, Tramonto, Tejeda, Moreno, et al., J. Chem. Phys. **143**, 064504 (2015)

Microgotas de agua subenfriada



Nozzle
- d=3.2 μm
- 966 kHz

Water droplets
- D=6.4 μm
- v=22 m/s



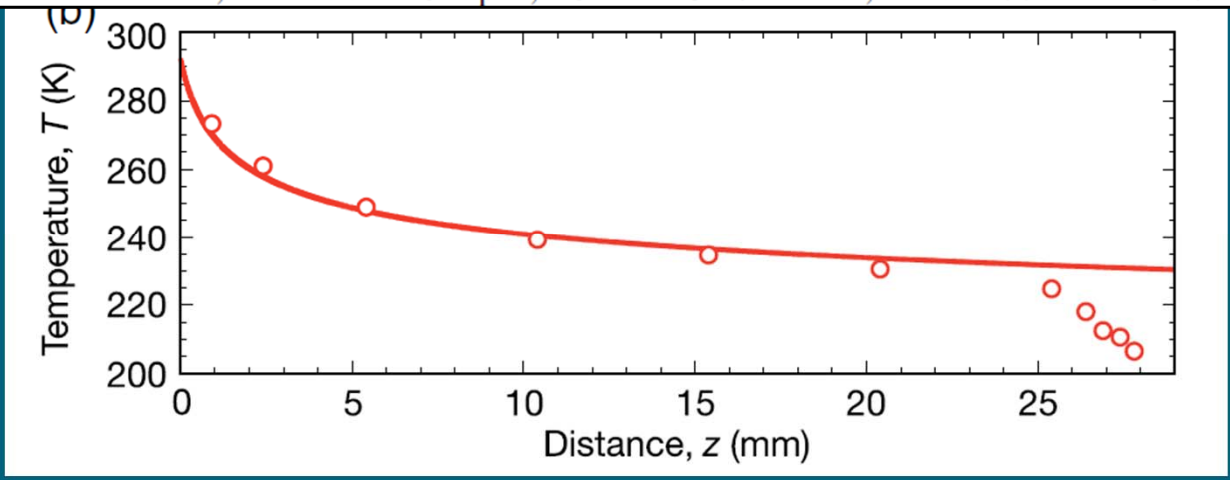
Results. Droplet size and temperature vs distance

PHYSICAL REVIEW LETTERS **120,** 015501 (2018)

Featured in Physics

Shrinking of Rapidly Evaporating Water Microdroplets Reveals their Extreme Supercooling

Claudia Goy,[1] Marco A. C. Potenza,[2] Sebastian Dedera,[3] Marilena Tomut,[4] Emmanuel Guillerm,[5] Anton Kalinin,[1,4] Kay-Obbe Voss,[4] Alexander Schottelius,[1] Nikolaos Petridis,[4] Alexey Prosvetov,[4] Guzmán Tejeda,[6] José M. Fernández,[6] Christina Trautmann,[4,7] Frédéric Caupin,[5] Ulrich Glasmacher,[3] and Robert E. Grisenti[1,4,*]



Goy et al. Phys. Rev. Lett. 120, 015501 (2018)

- Size-dependent resonances in the Raman spectra allow to measure the *droplet* size decrease from evaporative mass losses.
- A fraction of water droplets with initial diameter of **6379±12 nm** were found to remain liquid down to **230.6±0.6 K**.

Conclusiones

El FDM-lab ofrece formación en física molecular experimental, con un marcado carácter interdisciplinar:

- Espectroscopía Raman de altas prestaciones
- Láseres de potencia y técnicas ópticas relacionadas
- Dinámica supersónica y subsónica de fluidos
- Alto vacío y criogenia

Posibles temas de trabajo

• colisiones inelásticas de moléculas de interés atmosférico (CO_2, N_2, O_2) o astrofísico (+ He, H_2..)

• cartografía de densidad y temperatura de flujos evaporativos

• agregados moleculares pequeños de (H_2, H_2O, O_2, CO, etc)

• cristalización de microchorros/gotas de líquidos subenfriados

JAE-Intro