PRODUCTION OF PROTOPLANETARY ICE FOR COLLISION EXPERIMENTS

Investigation of a new experimental method to produce Amorphous Solid Water (ASW) particles

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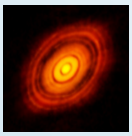
Overview :

What particle size ? Planet formation cycle

a) molecular cloud

T = 20 K
99% gas / **1% dust**



b) protoplanetary disk

Dust particles **accretion**

c) planet

mm-size	?	km-size
particles grow	?	particles grow
Van-der-Waals Forces	?	Gravity

size

Astronomy → Observation
Modelisation
Experiment

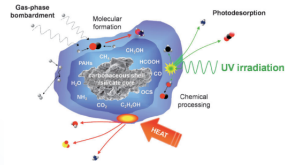
"How do planets form ?"

Produce **relevant protoplanetary ices** to perform collision experiments.

↓

sticking properties

What structure ? interstellar dust grain



Silicate or carbonaceous core coated by an **ASW layer**

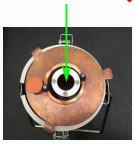
Experimental Setup and Procedure :

Cryo SEM : imaging of microscopic biological sample → Frozen by plunging into a **cryoliquid** (Ethane / Propane) [1]

1) Cryoliquid production :

Liquid Nitrogen T=77K

Ethane



Ethane properties :

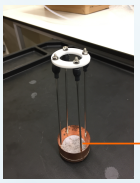
- *90.4 K ≤ liquid ≤ 184.6 K*
- **Thermal conductivity** : 248 mW/m K *at 100 K* [2]

2) Water droplet production/freezing :

Nebulizer → Produce a mist of water droplets
- **Droplet size** : 3.42 µm
- **Carrier gas** : N_2
- **Aspirator pressure** : 150 - 600 mbar

Heater

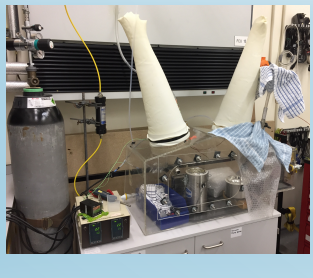
3) Sample recovery :

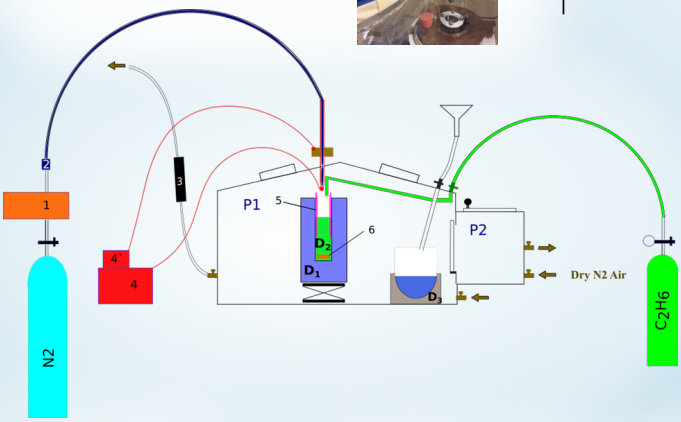


Particles transfer

D2 (Ethane) → **D3** (Nitrogen)

Sub mm membrane





Results :

1) Neutron Scattering :

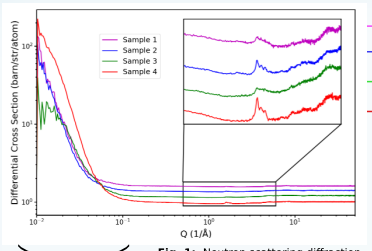


Fig. 1: Neutron scattering diffraction of our 4 samples

1 **non crystalline** → broad peak in 1.6 to 1.8 A region
2 crystalline
3 **non crystalline**
4 crystalline → 3 sharp peaks

Ice phase

↓

experimental conditions

specific surface area proportional to intensity in low Q region

↓

Surface structure [3]

Sample	Ethane T range (°C)	Aspirator vapor pressure (mbar)	Net D2O spraying time (min)	Transfer time
1	*	200	10	*
2	-125 to -100	150	20	Long
3	-166 to -135	200	30	Particles submerged
4	-149 to -124	500 - 600	30	Normal (5s)

Fig. 2: Table of the different experimental parameter for the 4 samples

2) Infrared :

Ethane matrix isolation in N 2 (1 : 50 ratio)

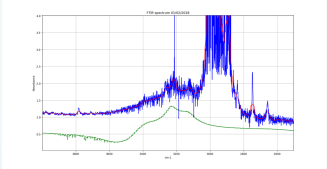


Fig. 3: IR spectrum (blue = sample made in ethane, green = sample made in N2, red = smoothed data)

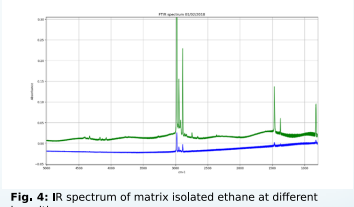


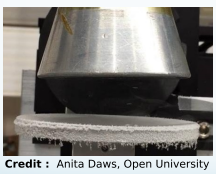
Fig. 4: IR spectrum of matrix isolated ethane at different deposition pressure

Impurities → Ethane in our samples !!

Further steps :

Experimental improvments :

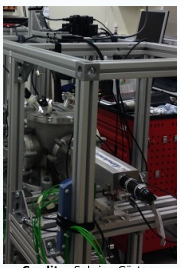
- Ethane temperature monitoring
  Control of ethane T by automated N2 top-up
- Avoiding Ethane contamination
  New way to recover the particles
  ↓ PhD
  reproductible



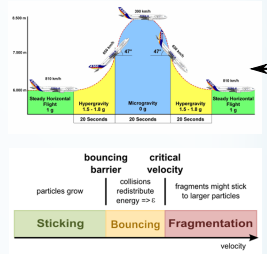
Credit : Anita Daws, Open University

→ Accoustic levitation → IR characterisation
→ Particles motion studies

Collision experiments :



Credit : Sabrina Gärtner, Open University



Parabolic flights → Allow very low velocities

Aknowledgements :

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References :

[1] Mayer & Br ggeller, **1982**, Nature, 298, 715-718
[2] www.engineeringtoolbox.com
[3] S. Gärtner, B. Gundlach, T.F. Headen, J. Ratte, J. Oesert, S.N. Gorb, T.G.A. Youngs, D.T. Brown, J. Blum, H.J. Fraser, Astrophys J, **2017**