

# NUCLEAR NUclear CLustering Effects in Astrophysical Reactions

# **Kick-off Meeting**

Edinburgh, May 15<sup>th</sup> 2025

https://www.erc-nuclear.uk

# Welcome and Overview

#### ERC-NUCLEAR Kick-off Event - 15 May 2025

09:30	09:45	welcome and introductions	Marialuisa (MLA)
09:45	10:00	ERC Overview	MLA
10:00	10:40	Scientific Goals	Michael + MLA
10:40	11:00	discussion	
11:00	11:30	coffee break	
		Experimental Programme	
11:30	12:00	10B(a,p) and 10B(a,d)	Jamie
12:00	12:30	10B(a,n)	Rhys
12:30	13:00	6,7Li(a,g)	Alessandro
13:00	14:00	Lunch & Photo	
		Computational Programme	
14:00	14:40	First Stars: Stellar Models and Nucleosynthesis	Marco
		Theoretical Programme	
14:50	15:30	Reactions with clusters	Guillaume
15:30	16:00	Coffee Break	
16:00	16:40	R-matrix developments	James
16:40	17:00	Closing Remarks and Next Steps	
10.30		Dinner at Nek's Kitchen by the Castle	
13.50		Diffiel at Nok's Kitchen by the Castle	

The Project in a Nutshell

## NUclear CLustering Effects in Astrophysical Reactions

## NUCLEAR



European Research Council



UK Research and Innovation Nucleosynthesis in First Stars and Other Puzzles

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## **Long-Standing Questions in Nuclear Astrophysics**



## **Q1.** Cosmological Lithium Problem



**Standard Model of Particle Physics** 

+ Cosmology

## Q2. Nucleosynthesis in First Stars



made of pristine H and He very massive  $\rightarrow$  need CNO nuclei



Chemical Evolution of Early Universe + Astronomical Observations (JWST)

## **Q3. Electron Screening Puzzle**



discrepancy between experiment and theory remains unexplained

Reactions in Plasmas Fusion-driven Energy Generation



## **Long-Standing Questions in Nuclear Astrophysics**



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## **Q1.** Cosmological Lithium Problem



factor of 3 discrepancy between observed and predicted Li abundance

## **Q2.** Nucleosynthesis in First Stars



made of pristine H and He very massive  $\rightarrow$  need CNO nuclei

### **Q3. Electron Screening Puzzle**



discrepancy between experiment and theory remains unexplained



key to unlock all three puzzles

## **Nuclear Clustering**











lower Coulomb barrier  $\rightarrow$  enhanced fusion

## **Idea and Current Status**





M Aliotta

## **Work Programme and Outcomes**







- $\alpha$ +Li and  $\alpha$ +B reactions (Q1-Q3)
- ultra-low background @LUNA
- lowest-energy data (world best)



- nucleosynthesis networks (NuGRID)
- impact on Q1 and Q2

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**Experimental Program:**  $\alpha$ -induced reactions on Li and B isotopes



optimize information transfer across boundaries

for accelerated progress with widest impact



Theoretical Program



**Computational Program** 

M Aliotta

NUCLEAR

## Timeline



		NUCLEAR: NUclear CLustering Effects in Astrophysical Reactions										
		PI: Mar	ialuisa Aliott	а								
Task	Assigned to	Year 1			Year 2		Year 3		Year 4		Year 5	
WP1: Experimental program		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	
T1a	PhD1, PDRA1, PI				M1a							
T1b	PhD2, PDRA1, PI							M1b				
WP2	2: Theoretical program											
T2a.1	PDRA2, GH				M2a.1							
T2a.2	PDRA2, GH					M2a.2						
T2b.1	PDRA2, JdB											
T2b.2	PDRA2, JdB									M2b		
T2b.3	PDRA2, JdB, PI										M2b	
WP3: Computational program												
T3.1	PDRA1, PDRA3, PI					M3.1						
T3.2	PDRA3, MP							M3.2				
T3.3	PDRA3, MP										M3.3	
Direction and Oversight												
	PI											

#### Milestones

M1a: low-energy cross sections data for 10B+a reactions

M1b: low-energy cross sections data for 6,7Li+a radiative captures

M2a.1: theoretical evaluation of reaction cross sections with N isotopes as compound nuclei

M2a.2: complete theoretical evaluation of radiative capture cross sections

M2b: evaluation of uncertainty in R-matrix fits and extrapolation with inclusion of improved potential models and electron screening

M3.1: initial stellar reaction rates evaluations from available and new experimental data (from WP1) as they become available

M3.2: nucleosynthesis calculations in first-generation stars (zero metallicity) with input from from T3.1

M3.3: complete nucleosynthesis simulations for largest progenitor stellar masses

## Grant Start Date: 2 December 2024







Marialuisa Aliotta

PRINCIPAL INVESTIGATOR

People Outputs Collaborations Contact Home News Project

## https://www.erc-nuclear.uk



Michael Wiescher (ex-officio scientific advisor) Meet the Team



**Guillaume Hupin** TEAM MEMBER



**Richard James deBoer** TEAM MEMBER



Marco Pignatari TEAM MEMBER

# **Other Team Members**

## **PhD Students**



Jamie Jones, PhD (September 2024)



Rhys Bonnell, PhD (December 2024)



Lavinia Dall Vedova (September 2025)







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