SHADES

$^{22}\text{Ne}(\alpha,n)^{25}\text{Mg}$ in the Gamow window

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on behalf of the SHADES project

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Virtual workshop on $(\alpha,n)$ reactions for astrophysics
• H, He, Li produced during Big Bang
• Almost all elements > Li produced in stars
• A < Fe produced through charged-particle capture
• A > Fe: neutron capture (r-process, s-process, p-process)

- $^{22}\text{Ne}(\alpha,n)^{25}\text{Mg}$ main neutron source in massive stars (M>8$\text{M}_\odot$) for the synthesis of A = 60-90 elements
- neutron source with $^{13}\text{C}(\alpha,n)^{16}\text{O}$ in TP-AGB stars for the synthesis of A = 90-209 elements
- only upper limits at the lower energies
- unknown resonance in the lower energy region
- $\alpha$-width of $E < 835$ keV states mostly unknown or highly uncertain

<table>
<thead>
<tr>
<th>$E_x$ [keV]</th>
<th>$E_x$ [keV]</th>
<th>$E_\alpha$ [keV]</th>
<th>$J_\pi$</th>
<th>$\Gamma_n$ [eV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.92</td>
<td>11112</td>
<td>589</td>
<td>2+</td>
<td>2095</td>
</tr>
<tr>
<td>72.82</td>
<td>11163</td>
<td>649</td>
<td>2+</td>
<td>5310</td>
</tr>
<tr>
<td>79.23</td>
<td>11169</td>
<td>656</td>
<td>3-</td>
<td>1940</td>
</tr>
<tr>
<td>187.95</td>
<td>11274</td>
<td>779</td>
<td>2+</td>
<td>410</td>
</tr>
<tr>
<td>194.01</td>
<td>11280</td>
<td>786</td>
<td>3-</td>
<td>1810</td>
</tr>
<tr>
<td>243.98</td>
<td>11328</td>
<td>843</td>
<td>?</td>
<td>171</td>
</tr>
<tr>
<td>235</td>
<td>11319</td>
<td>832</td>
<td>2+</td>
<td>Total = 250 eV</td>
</tr>
</tbody>
</table>

Virtual workshop on $(\alpha,n)$ reactions for astrophysics

Wednesday, July 14, 2021
**Scintillator-He3 Array for Deep-underground Experiments on the S-process (SHADES)**

**Goals**
- highly sensitive resonance search for the reaction between the neutron threshold and the 832 keV
- two order of magnitude in increasing of the sensitivity respect the status of the art
- high precision measurement of the 832 keV resonance energy and strength
- higher energy measurements to grant a wide overlap with literature data

Scintillator-He3 Array for Deep-underground Experiments on the S-process (SHADES)

Methods
- underground facility at LNGS
- high current accelerator with LUNA-MV
- recirculating Ne-22 gas target
- novel scintillator-3He array to supress BIB and identify neutrons
- astrophysical evaluations
Methods

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- cosmic ray suppression deep underground
- $\alpha$-background reduction with steel counters
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- 3.5 MeV Singletron Accelerator with ECR source
- 500 μA of high energy resolution $^4$He beams
- high stability for long measurement runs
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- 30 keV $^{22}$Ne extended gas target
- 165° RBS beam current monitor
- pressure and temperature gauges
- carbon free: tantalum covers, aluminium sealings, "silicon industry" pumps, purifier
- building phase, soon IBA characterization
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- 12 EJ309 scintillators (spectra energy & moderation) - 18 $^3$He counters (gate)
- compact: high detection efficiency (~20%)
- neutron/gamma PSD
- custom DAQ software
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- impact on a complete mass and metallicity range stars through the PPN code (M. Pignatari)
- 5000-10000 CPU hours at the HPC facility viper in Hull University
SHADES schedule

- array and gas target design - complete
- array characterization - ongoing, first underground tests at LNGS (end of July 2021)
- gas target characterization - ongoing, IBA measurements (autumn-winter 2021)
- preparation for underground measurements - spring-winter 2022
- $^{22}\text{Ne}(\alpha,\text{n})^{25}\text{Mg}$ rate measurement - 2023
- R-Matrix analysis and nucleosynthesis calculations - 2024
Scintillator-He3 Array for Deep-underground Experiments on the S-process (SHADES)

Team
- A. Best (PI) - University of Naples "Federico II"
- C. Ananna - University of Naples "Federico II"
- A. Boeltzig - University of Naples "Federico II"
- A. Di Leva - University of Naples "Federico II"
- G. Imbriani - University of Naples "Federico II"
- M. Junker - INFN-LNGS
- M. Pignatari - Hull University
- D. Rapagnani - University of Naples "Federico II"

open positions for ph.D. students and postdocs

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