Investigation of Pygmy Dipole Resonance in Iron neutron rich exotic isotopes

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Pygmy Dipole Resonance in neutron rich nuclei
E1 strength investigation of $^{62,64}$Fe nuclei with relativistic coulomb excitation
PreSPEC-AGATA setup at GSI
Experimental gamma ray spectra from $^{62,64}$Fe
Preliminary results
Conclusions
Pygmy Dipole Resonance in neutron rich nuclei

E1 strength response measured in neutron rich stable nuclei

Accumulation of strength around and above neutron separation energy interpret as a collective motion called Pygmy Dipole Resonance (PDR)

Experimental effort over 40 years to investigate this strength accumulation in different mass region towards exotic nuclei


P. Aldrich et al. PRL 95 (2005) 132501

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Pygmy Dipole Resonance in Iron

This low energy region contribution of PDR has attracted interest and it was measured in different region of mass.

R. Massarczyk et al., PRL 112, 072501

A. C. Larsen et al., PRL 111, 242504 (2013)
Iron isotopes

Theoretical predictions show dipole strength around 10 MeV and also below the threshold for $^{62,64}$Fe.

For the first time E1 strength distribution below the threshold will be studied for exotic isotopes at varying of the neutron number.

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**$^{62}$Fe: expected dipole strength**

- Ar. Un.
- Energy [MeV]

**$^{64}$Fe: expected dipole strength**

- Ar. Un.
- Energy [MeV]

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Relativistic coulomb excitation of Pygmy Dipole Strength

High selectivity
No neutron-threshold effect

Pygmy Dipole Strength measured for the first time in exotic nuclei: $^{62,64}\text{Fe}$ coulomb excitation experiment in GSI

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PreSPEC-AGATA setup to investigate exotic nuclei

FRS
production and selection of exotic nuclei

LYCCA
selection of coulomb excitation events on secondary target

AGATA – HECTOR
Measurement of gamma decay of:
  first $2^+$ state
  High energy levels

EPJ Web of Conferences 66, 02083 (2014)
PreSPEC-AGATA setup

AGATA coupled with HECTOR allows to cover a wide angular range. This can be used to get informations on the multipolarity of gamma rays detected. In addition backward scintillators can be used for the estimation of background.

<table>
<thead>
<tr>
<th>AGATA</th>
<th>From 15° to 60°</th>
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<tbody>
<tr>
<td>HECTOR</td>
<td>22°, 68°, 95°, 142°</td>
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Relativistic coulomb excitation selection @ GSI

Identification of beam of interest

Identification of reaction

Scattering angle

ΔE (arb. Un.)

E (arb. Un.)
Ground State 2\(^{+}\) 877 keV

Thick target and relativistic (440 MeV/nucl.) beam required a fine tuning of PreSPEC and AGATA detectors to observe 2\(^{+}\) state decay for both iron isotopes

\[ B(E2) \] of 2\(^{+}\) decay is known and it is used to provide a normalization for the cross section\(\to\) essential to deduce \[ B(E1) \] from the high energy \(\gamma\)-transition
High energy spectra

Angular distribution was used to deduce the E1 character of the γ-ray data above 6 MeV.
γ yield in the pygmy region

How would be the spectrum if the GDR response is pure lorentzian?

Pure Lorentzian GDR shape and spectrum of virtual photons used to obtain excitation spectrum.
\( \gamma \) yield in the pygmy region

GEMINI code used to deduce de-excitation gamma yield from the excitation spectrum

AGATA response function applied to de-excitation gamma yield
High energy spectra show statistics accumulations above the background (evaluated with backward angle LaBr) and the GDR tail contribution.

**$^{64}$Fe AGATA spectrum**

**$^{62}$Fe AGATA spectrum**
Conclusions and Perspectives

- E1 strength accumulation at one particle separation energy has attracted interest because it is relevant for both nuclear structure and astrophysics.
  - A lot of data available for stable nuclei, data about exotic nuclei very scarce.

- E1 response just below the threshold is under investigation.

- Measurement of E1 response of $^{64,62}\text{Fe}$ by relativistic coulomb scattering at GSI laboratories.

- The advanced features of the setup allowed to collect interesting data for both Iron isotopes.

- Gamma ray energy spectra show interesting structures over the GDR tail: the analysis showed the possibility to get an estimation of $B(E1)$ value related to high energy $\gamma$ ray transitions.
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Thank you for your kind attention