

11-13 September 2019, Bitlis, TURKEY

### CONTENTS

Contents	1
Committees	4
Honorary Committee Organising Committee Scientific Committee	4 4 5
Scientific Program	7
Invited Talks	.11
The Rotational, Translational and Galilean Invariant Model for Dipole States in QRPA	<mark>12</mark>
Gamow-Teller Strength and Electron Capture Cross Section calculation by pn-QRPA for selected fp-sh nuclei	ell 13
Fusion in massive stars: Pushing the 12C+12C cross-section to the limits with the STELLA experiment IPN Orsay	at .14
Study of the shell evolution effect on the nuclei around the 78Ni core structure	.15
Shell-model study of the nuclear structure of 27Si nucleus	16
Multi-nucleon transfer in Ni + Ni and Xe + Pb reactions	.17
Nuclear Power Plant Projects and Nuclear Engineering Education in Turkey	18
Oral Presentations	.1 <b>9</b>
Prognostication of Shock Wave Influence During Nuclear Blast	.20
The ionizing radiation dose of the new designed cerrobend blocks are simulated with GATE for differen SSD and radiation field	t .21
Exploring nuclear collectivity at low spins in 167Lu nucleus	22
The calculation of K Shell XRF Parameters of Some First Inner Transition Metals	23
The concentration effect to k-shell fluorescence cross sections of TixCo1-x alloys	.24
High temperature X-ray diffraction study of Tantalum – Carbides phases	25
High temperature X-ray diffraction study of Tantalum – Oxides phases	.26
Bubble Structure in Exotic Nucleİ	.27
Evolution of collectivity in 164W as a function of spin-quantum number	.28
Determination of the efficiency of NaI(TI) detector by gate simulation program	.29
Calculations of Spontaneus Fission (SF) half-lives of superheavy nuclei in different models	30
Production of conversion electron sources for measurements of internal conversion coefficients (ICC)	.31
Nuclear Structure Properties of Some Isotopes around 78Ni	.32
Production of hypermatter and hypernuclei in relativistic hadron and ion collisions	.33
Construction of Translation-Invariant U(N) Non-Commutative Gauge Model university of medea algeria	.34
Nuclear lattice calculations with chiral effective field theory	.35
Study of the log(ft) values in spherical and deformed nuclei for some odd-A germanium isotopes	36
Weak Imaginary potential Effect on the 18,19,200 + 12C Fusion Reactions at Low Energies	.37

11-13 September 2019, Bitlis, TURKEY

Calculation of radiogenic heat productions from marble and glazed tiles used as covering building materials in Turkey	.38
Evalution of the excess life time cancer risk due to natural radioactivity in tap water consumed in Nevşehir	39
Alpha and Spontaneous Fission Half-life Predictions of Uranium Isotopes	.40
Nuclear Shell Model Calculations For Ca Isotopes	.41
Energy loss analysis from RBS spectrum of thin Cu <sub>2</sub> ZnSnS <sub>4</sub> (CZTS) film	42
Internal Bremsstrahlung Spectrum of (_37^86)Rb for Forbidden Beta Transition	.43
The Deconvolution of the Nal (TI) Detector Response Function for Continuous Energy Photon Spectrum by SVD Approach	44
Improving Nuclear Quadrupole Resonance (NQR) Spectra Using Weak/High Magnetic Field and the Defective (NQR) Pulse Separation.	45
Investigation of some structural properties of even-even zirconium isotopes within IBM-1 Model	46
Treatise of Angular Distributions of <sup>3</sup> He Elastic Scattering from Stable Selenium İsotopes	47
Allowed GT and First Forbidden Transitions in <sup>71,73,75</sup> Se Isotopes	48
Half-life of the medical radioisotope Lu-177 for Targeted Radionuclide Therapy	49
Turkey's political economy of nuclear energy	50
An Application of Different Nuclear Potentials on the CDCC Model	51
Dissipative dynamics within stochastic mean-field approach	52
Production of Platinum Isotopes via Sub-Barrier Fusion Cross Sections of <sup>16</sup> O from Stable Ytterbium Isotopes	53
Microscopic description of the giant dipole resonance (GDR) mode in <sup>165</sup> Ho	<mark>54</mark>
Comparission of E1 Response of <sup>154</sup> Sm and <sup>155</sup> Sm in the Pygmy Dipole Resonance (PDR) Region	<mark>.55</mark>
National regulatory provision of designing and operating for safety of nuclear power plant	56
Effect of deformation on Gamow-Teller Strength and Electron Capture Cross-section for Chromium Isotopes (46-50Cr) using QRPA	) pn- 7
Applications of Nuclear Science: Neutron Features and Neutron Interactions with Matter	58
Investigation of (n,p) and (γ,p) Reaction Cross-Sections of Zr Isotopes Used as Imaging Tracers	59
Radiation Absorption Properties of Pb(NO <sub>3</sub> ) <sub>2</sub> Doped Wallpapers	60
Determination of first two excited states of even-even nuclei by an artificial intelligence method	61
What causes the High Radiation Risk of Volcanic and Pyroclastic Rocks Using as Building Materials from Isparta Volcanic Region, SW Turkey	62
The Radioisotope Activity Concentrations of Some Medical and Aromatic Plants Growing in Bitlis	63
The Analyzing Statistically of Radon Concentrations in Some Plants Growing in Bitlis	64

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11-13 September 2019, Bitlis, TURKEY

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11-13 September 2019, Bitlis, TURKEY

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11-13 September 2019, Bitlis, TURKEY

### The Rotational, Translational and Galilean Invariant Model for Dipole States in QRPA

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In this review the QRPA approach with the rotational and translational invariant Hamiltonian with Galileo invariant pairing interaction has been carried out to describe magnetic and electric dipole excitations in deformed nuclei. Calculations show that the deformed nuclei demonstrates a very rich B(M1) strength structure and in some aspects nicely confirm the experimental data. It has been shown that the main part of 1+ states, observed at 2–4 MeV may be attributed to have a M1 character and may be interpreted as the main fragments of the scissors mode. The agreement between the calculated mean excitation energies as well as the summed B(M1) values of the scissors mode and the available experimental data is quite good. The calculations indicate the presence of a few prominent negative-parity K $\pi$  = 1– states in the 2–4 MeV energy interval. This suggests that the supposition of the experiment "all stronger  $\Delta K$  = 1 low-lying dipole excitations were of magnetic character" cannot be generalized. These results show the necessity of explicit parity measurements for the correct determination of the scissors mode strength in deformed nuclei.

11-13 September 2019, Bitlis, TURKEY

# Microscopic description of the giant dipole resonance (GDR) mode in <sup>165</sup>Ho

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The study of the giant dipole resonance (GDR), originating from the collective motion of neutrons against protons in the nucleus, provides basic insight into the isovector properties of the nuclear force and is quite helpful to understand the properties of the interaction between the nucleons. In this study, GDR mode in well-deformed <sup>165</sup>Ho has been investigated in the framework of the Translation and Galilean Invariant Quasiparticle Phonon Nuclear Model (TGI-QPNM). Excitation energies, reduced  $B(E1)\uparrow$  probabilities and total photoabsorption cross sections have been calculated for  $\Delta K$ =0 and  $\Delta K$ =1 transitions. It has been found that the GDR spectrum in this nucleus is highly fragmented into several apparent peaks due to the quasiparticle⊗phonon interactions. The results of the total photoabsorption cross section are also in qualitative agreement with the experimental results.

11-13 September 2019, Bitlis, TURKEY

### Comparission of *E*1 Response of <sup>154</sup>Sm and <sup>155</sup>Sm in the Pygmy Dipole Resonance (PDR) Region

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The dipole response associated with the pygmy dipole resonance (PDR) in <sup>154</sup>Sm and <sup>155</sup>Sm has been studied. In the <sup>154</sup>Sm nucleus 1<sup>-</sup> phonons with *K*=0 and *K*=1 branches have been calculated using the Translation and Galilean Invariant Quasiparticle Random Phase Approximation (TGI-QRPA). The structure of the more pronounced electric dipole (*E*1) peaks in PDR region in <sup>154</sup>Sm is composed of predominantly two-quasiproton or two-quasineutron states. The calculations in <sup>155</sup>Sm has been performed in the framework of the Translation and Galilean Invariant Quasiparticle Phonon Nuclear Model (TGI-QPNM) based on the TGI-QRPA 1<sup>-</sup> phonons calculated for <sup>154</sup>Sm. When going from <sup>154</sup>Sm to neighbouring <sup>155</sup>Sm, the fragmentation of the *E*1 strength is dramatically enhanced. The results emphasize the role of the quasiparticle & phonon interactions in enhancing the fragmentation of the strength in the PDR region in <sup>155</sup>Sm. Even though the strong fragmentation of the *E*1 strength obtained for <sup>155</sup>Sm, in 6-10 MeV energy region the summed *E*1 strength is comparable to that in <sup>154</sup>Sm. The results indicate that one quasiparticle behaves solely as a spectator in <sup>155</sup>Sm.