Gamow-Teller Transitions for Neutron-Rich Nuclei in
the Superburst by the Deformed Quasi-particle
RPA(DQRPA)

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Abstract. We developed the deformed quasi-particle random phase approximation (DQRPA)
for the Gamow-Teller (GT) transition for even-even deformed nuclei. We started from the
deformed axially symmetric Woods-Saxon potential based on the Nilsson basis, and performed
deformed BCS and deformed QRPA. In this work, we used a realistic two-body interaction taken
by Brueckner G-matrix based on the Bonn potential. For the application, we calculated the GT
transition for the deformed nuclei at the surface of the neutron star, where electron captures
are important heat sources for the carbon flash.

1. Introduction
In the core collapsing supernovae(SN), medium and heavy elements are believed to be produced
by the rapid successive neutron capture, r-process. In this process, many kinds of unstable
nuclei are produced and decayed within fractions of a second. At this stage, they interact with
neutrinos as well as other particles. Since parts of them are thought to be strongly deformed, we
have to explicitly consider such deformations in the reactions. The crust of a neutron star with
a companion star is more important site for the nucleosynthesis, in specific, the rapid proton
process. Because of the strong gravitation on the neutron star surface, one expects hydrogen rich
mass flow from the companion star. Moreover, the crust has high density and low temperature,
which makes electrons degenerated. By this degeneration, beta decays are Pauli blocked. It
means that neutron rich nuclei become stable nuclei, but unstable nuclei become stable in this
situation.

Up to now, most of the conventional approach to understand the nuclear structure is based
on the spherical symmetry. In order to describe neutron-rich nuclei produced in the r-process,
one needs to develop a formalism including explicitly the deformation [1, 2, 3, 4]. As the
mass number increases, the application of the shell model may have actual limits because of
tremendous increase of configuration mixing due to the deformation. We extend our previous
QRPA based on the spherical symmetry [5].

2. Formalism
2.1. Description of ground states with nn, pp, and np pairing correlations
The total nuclear Hamiltonian is given as
\[ H = H_0 + H_{\text{int}} \] (1)
\[ H_0 = \sum_{\alpha p, \alpha' o} \epsilon_{\alpha p, \alpha' o} c_{\alpha p, \alpha' o}^\dagger c_{\alpha p, \alpha' o} \quad (\alpha' = p, n) \]
\[ H_{\text{int}} = \sum_{\alpha \beta \delta p, \alpha' \beta' \delta' p, \alpha' \beta' \delta' \delta' o} V_{\alpha \alpha' \beta \beta' \gamma \gamma' \delta \delta'} c_{\alpha p, \alpha' o}^\dagger c_{\beta p, \beta' o} c_{\delta p, \delta' o} c_{\gamma p, \gamma' o}, \]

where the interaction matrix \( V \) is the antisymmetrized interaction with the Baranger hamiltonian [6] in which two \( \frac{1}{2} \) factors, from J and T coupling, are included, so that the \( H_{\text{int}} \) in Eq. (1) is equivalent to the usual \( H_{\text{int}} = \frac{1}{4} \sum_{\alpha, \beta, \delta} \alpha' \beta' \delta' \delta' \sum \epsilon_{\alpha, \beta, \delta} c_{\alpha', \beta', \delta'}^\dagger c_{\alpha, \beta, \delta} c_{\beta, \delta, \delta'} c_{\beta', \delta', \delta'} \). The Greek letters denote proton or neutron single particle states with projection \( \Omega \) of the total angular momentum on the nuclear symmetry axis and parity \( \pi \). The isospin of particles is denoted as a Greek letter with prime and the isospin of quasi-particles is expressed as a Greek letter with double prime. The operator \( c_{\alpha p, \alpha' o}^\dagger \) (\( c_{\alpha p, \alpha' o} \)) stand for the usual creation (destruction) operators of the real particle in the state of \( a \) with an isospin \( \alpha' \) and \( c_{\alpha p, \alpha' o}^\dagger \) is the time reversed operator of \( c_{\alpha p, \alpha' o} \). \( \epsilon_{\alpha p, \alpha' o} \) is the single particle energy. The \( \rho \) (\( \rho = \pm 1 \)) is the sign of the angular momentum projection \( \Omega \) and intrinsic states are twofold-degenerate. The state \( \Omega_{\alpha} \) and \( -\Omega_{\alpha} \) are for a state and its time-reversed state. The single particle states \( |\alpha \Omega_{\alpha} \rangle \) of protons or neutrons are calculated by solving the Schroedinger equation with the deformed axially symmetric Woods-Saxon potential. The deformed Woods-Saxon s.p. wave functions \( |\alpha \Omega_{\alpha} \rangle \) with \( \Omega_{\alpha} > 0 \) are composed of two parts which are the deformed harmonic oscillator s.p. wave function \( |Nn_z \Lambda \rangle \) and the spin wave function \( |\Sigma \rangle \):

\[ |\alpha \Omega_{\alpha} \rangle = \sum_{Nn_z, \Sigma} b_{Nn_z, \Sigma} |Nn_z \Lambda \rangle \Sigma \rangle, \]

where \( N = n_\perp + n_z \) (\( n_\perp = 2n_p + \Lambda \)) is a major shell number and \( n_z \) and \( n_p \) are the number of nodes the deformed harmonic oscillator wave functions in the \( z \) and \( \rho \) directions, respectively. \( \Lambda \) and \( \Sigma \) are the projections of the orbital and spin angular momentum onto the nuclear symmetric axis \( z \). The deformed harmonic oscillator wave functions \( |Nn_z \Lambda \rangle \) is expanded in terms of the wave functions of the spherical harmonic oscillator \( |n_r \Lambda \rangle \). \( n_r \) is the radial quantum number and \( l \) is the orbital angular momentum. The wave function Eq. (2) can be expressed as

\[ |\alpha \Omega_{\alpha} \rangle = \sum_{\alpha} B_{\alpha}^\alpha |a \Omega_{\alpha} \rangle, \]

where the Roman letter indicates the quantum numbers \( (n_r, l) \) of a nucleon state and \( |a \Omega_{\alpha} \rangle = \sum_{\Sigma} C_{l \Lambda, \Sigma} B_{\alpha}^\alpha |n_\Lambda \rangle \Sigma \rangle \) is the spherical harmonic oscillator wave function \( (B_{\alpha}^\alpha = \sum_{L=0}^{\alpha} B_{\alpha}^\alpha) \). The spatial overlap integral \( A_{Nn_z, \Lambda}^{n_r \Lambda} = \langle n_\Lambda | Nn_z \Lambda \rangle \) can be numerically calculated in the spherical coordinate system and \( C_{l \Lambda, \Sigma}^{\alpha \Omega_{\alpha}} \) is a Clebsch-Gordan coefficient of the coupling of the orbital and spin terms.

We transform this hamiltonian in Eq. (1) by the HFB transformation to quasi-particles,

\[ a_{\alpha}^{\dagger} \rightarrow \sum_{\beta, \delta} \left( u_{\alpha \alpha'} \beta \delta \beta' \delta' + v_{\alpha \alpha'} \beta \delta \beta' \delta' \right) a_{\beta \delta}^\dagger, \quad a_{\alpha} = \sum_{\beta, \delta} \left( u_{\alpha \alpha'} \beta \delta \beta' \delta' + v_{\alpha \alpha'} \beta \delta \beta' \delta' \right) \]

The Hamiltonian can be represented in terms of the quasi-particles as follows

\[ H' = H_0' + \sum_{\alpha \alpha'} E_{\alpha \alpha'} a_{\alpha \alpha'}^\dagger a_{\alpha \alpha'} + H_{\text{qp.int}}. \]

Using the transformation of Eq.(4) we obtain the following HFB equation.
chosen by the selection rules $\Omega$ functions of the intermediate states in the laboratory frame that have a projection $M$ of the total vacuum for quasi-particle. Excited states term formula for these isotopes [7].

$\alpha \alpha p$ will be represented at the next section. $\Delta J = 0$ is the energy of a quasi-particle with the isospin quantum number $\alpha''$ in the state $\alpha$. If we neglect $\Delta np$, this equation reduces to the standard BCS equation. Eq. (6) is solved by using a Brueckner reaction matrix of the realistic Bonn potential for the nucleon-nucleon interaction. The pairing potentials $\Delta p$, $\Delta n$ and $\Delta pn$ in Eq.(6) are defined in the following way

$$\Delta_{\alpha p \alpha} = \frac{1}{2} \frac{1}{(2a + 1)^{1/2}} \sum_{JCE} g_{pp}(g_{nn}) F_{\alpha\alpha\alpha \alpha}^{J0} F_{\gamma \gamma \gamma \gamma}^{J0} G(\alphaacc, J) (2c + 1)^{1/2} (u_{1p} v_{1p} + u_{2p} v_{2p})$$  \hspace{1cm} (7)$$

where $F_{\alpha\alpha\alpha \alpha}^{J0}$ will be represented at the next section. $\Delta_{\alpha \alpha n}$ is the same as Eq. (7) but $n$ instead of $p$. In order to renormalize the G-matrix, theoretical values are adjusted to the empirical pairing potentials $\Delta_{\alpha p \alpha}^{emp}$, $\Delta_{\alpha n}^{emp}$ and $\Delta_{\alpha p n}^{emp}$ by multiplying the G-matrix with a strength parameters $g_{pp}$, $g_{nn}$ and $g_{pn}$. The empirical pairing potentials of proton(neutron) are used by a symmetric five term formula for these isotopes [7].

2.2. DQRPA coupled by neutron-proton pairing

We take the ground state of the target nucleus, which is assumed as even-even nucleus, as BCS vacuum for quasi-particle. Excited states $|m; J^P M(K)\rangle$ in an intermediate nucleus are generated by operating the following one phonon operator to the correlated QRPA ground state. The wave functions of the intermediate states in the laboratory frame that have a projection $M$ of the total angular momentum onto the nuclear symmetric $z$ axis is calculated from the intrinsic frame. The one phonon operator is given as:

$$Q_{m,K}^J = \sum_{\alpha \beta} [X_{(\alpha \beta K)}^m A_{(\alpha \beta K)}^\dagger - Y_{(\alpha \beta K)}^m \tilde{A}(\alpha \beta K)].$$  \hspace{1cm} (8)$$

The two quasi-particle creation and annihilation operators are as follows

$$A_{(\alpha \beta K)}^\dagger = \sum_{\Omega \Omega_\beta} C_{J_{\alpha \beta \alpha \beta} \Omega_\alpha \Omega_\beta} a^\dagger_{\alpha} a^\dagger_{\beta}, \quad \tilde{A}_{(\alpha \beta K)} = \sum_{\Omega \Omega_\beta} C_{J_{\alpha \alpha \beta \beta} \Omega_\alpha \Omega_\beta} a_{\alpha} a_{\beta},$$  \hspace{1cm} (9)$$

where the bar denotes the time-reversal state for each state. The quasi-particle pairs $\alpha \beta$ are chosen by the selection rules $\Omega_\alpha - \Omega_\beta = K$ and $\pi_\alpha \pi_\beta = 1$. Two-body deformed wave function is given by

$$|\alpha \beta > = \sum_{abJ} F_{abJ}^J |ab, JK>,$$  \hspace{1cm} (10)$$

where $|ab,JK> = \sum_{J} C_{J_{\alpha \beta \alpha \beta} \Omega_\alpha \Omega_\beta} a_{\alpha a} |b\Omega_\beta >$, and $F_{abJ}^J = B^\alpha_a B^\beta_b (-1)^{J_\lambda - \Omega_\lambda} C_{J_{\alpha \alpha \beta \beta} \Omega_\alpha \Omega_\beta}$ is defined with the phase $(-1)^{J_\lambda - \Omega_\lambda}$ arising from the time-reversed states $\beta$.

Our QRPA equation in deformed basis has the following form.

$$\begin{pmatrix}
A_{1111}^{1111}(K) & A_{1122}^{1122}(K) & A_{1112}^{1112}(K) & A_{1112}^{1111}(K) & B_{1111}^{1111}(K) & B_{1122}^{1122}(K) & B_{1112}^{1112}(K) & B_{1112}^{1112}(K) \\
A_{2222}^{1111}(K) & A_{2211}^{1122}(K) & A_{2222}^{1112}(K) & A_{2222}^{1111}(K) & B_{2211}^{1111}(K) & B_{2222}^{1122}(K) & B_{2222}^{1112}(K) & B_{2222}^{1112}(K) \\
A_{\alpha \gamma \alpha \gamma}^{1111}(K) & A_{\alpha \gamma \gamma \gamma}^{1111}(K) & A_{\alpha \gamma \gamma \gamma}^{1122}(K) & A_{\alpha \gamma \gamma \gamma}^{1112}(K) & B_{\alpha \gamma \gamma \gamma}^{1111}(K) & B_{\alpha \gamma \gamma \gamma}^{1122}(K) & B_{\alpha \gamma \gamma \gamma}^{1112}(K) & B_{\alpha \gamma \gamma \gamma}^{1112}(K) \\
-A_{\alpha \gamma \gamma \gamma}^{2211}(K) & -B_{\alpha \gamma \gamma \gamma}^{2211}(K) & -B_{\alpha \gamma \gamma \gamma}^{2222}(K) & -B_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2211}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K) \\
B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2211}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2211}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) \\
B_{\alpha \gamma \gamma \gamma}^{2211}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) & B_{\alpha \gamma \gamma \gamma}^{2211}(K) & B_{\alpha \gamma \gamma \gamma}^{2222}(K) \\
-B_{\alpha \gamma \gamma \gamma}^{2211}(K) & -B_{\alpha \gamma \gamma \gamma}^{2222}(K) & -B_{\alpha \gamma \gamma \gamma}^{2222}(K) & -B_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2211}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K) & -A_{\alpha \gamma \gamma \gamma}^{2222}(K)
\end{pmatrix}$$  \hspace{1cm} (11)$$

where 1 and 2 denote the isospin quantum numbers of protons and neutrons. The amplitudes $X_{\alpha\alpha''}\beta\beta''$ and $Y_{\alpha\alpha''}\beta\beta''$, which stand for forward and backward going amplitudes from state $\alpha\alpha''$ to $\beta\beta''$, are related to $\hat{X}_{\alpha\alpha''}\beta\beta'' = \sqrt{2}\sigma_{\alpha\alpha''}\beta\beta'' X_{\alpha\alpha''}\beta\beta''$ and $\hat{Y}_{\alpha\alpha''}\beta\beta'' = \sqrt{2}\sigma_{\alpha\alpha''}\beta\beta'' Y_{\alpha\alpha''}\beta\beta''$. $\sigma_{\alpha\alpha''}\beta\beta'' = 1$ if $\alpha = \beta$ and $\alpha'' = \beta''$, otherwise $\sigma_{\alpha\alpha''}\beta\beta'' = \sqrt{2}$. The A and B matrices are given by

$$A_{\alpha, \beta, \gamma}^{\alpha''\beta', \gamma''} (K) = (E_{\alpha''} + E_{\beta'}) \delta_{\alpha'\gamma'} \delta_{\beta'\gamma''} - \sigma_{\alpha\alpha''} \sigma_{\gamma\gamma''} \delta_{\beta\beta''} \times \left[ g_{pp}(u_{\alpha''}u_{\beta'}v_{\gamma'}v_{\delta'}) + v_{\alpha''}v_{\beta'}u_{\gamma'}u_{\delta''} \right] V_{\alpha\beta, \gamma\delta} \quad (12)$$

$$B_{\alpha, \beta, \gamma}^{\alpha''\beta', \gamma''} (K) = - \sigma_{\alpha\alpha''} \beta_{\beta'} \sigma_{\gamma\gamma''} \delta_{\beta\beta''} \times \left[ -g_{pp}(u_{\alpha''}u_{\beta'}v_{\gamma'}v_{\delta'}) + v_{\alpha''}v_{\beta'}u_{\gamma'}u_{\delta''} \right] V_{\alpha\beta, \gamma\delta} \quad (13)$$

$$V_{\alpha\beta, \gamma\delta} = \sum_{J} \sum_{abcd} F_{\alpha, \beta}^{JK} F_{\gamma, \delta}^{\gamma, \delta} G(abcd, J) \quad (14)$$

where $F_{\alpha, \beta}^{JK} = B_{\alpha}^{\beta} C_{J\alpha\beta}^{\gamma, \delta} (K' = \Omega_{\alpha} + \Omega_{\beta})$ is defined and $u(v)$ coefficients are determined from the HFB calculation with the pairing strength $g_{nn}, g_{pp}$ and $g_{np}$ adjusted to the empirical pairing gaps $\Delta_{nn}, \Delta_{pp}$ and $\delta_{np}$, respectively. $E_{\alpha''}$ indicates the quasi-particle energy of the state $\alpha$ with the quasi-particle isospin $\alpha''$. The $G(F)$ matrices are two body particle - particle (hole) matrix elements obtained as solutions of the Bethe - Goldstone equation from the Bonn potential [8].

2.3. Description of Gamow-Teller transition

The $\beta^{-}$ transition amplitudes in intrinsic frame, $<1(K), m|\hat{M}_{\beta}^{-}|QRPA>$, can be represented by one in laboratory frame, $<1M|\hat{M}_{L-M}^{-}|QRPA>$. Here operator $\beta_{\mu}^{\pm}$ decay is defined as

$$\hat{\beta}_{L-M}^{-} = \hat{L}^{-1} <p||\hat{\beta}||n > [c_{\mu}^{+}\bar{c}_{n}]_{LM} \quad (15)$$

and the $\hat{\beta}_{M}^{\pm}$ transition operator in the laboratory frame are related with intrinsic $\beta_{\mu}^{\pm}$ operator as follow:

$$\hat{\beta}_{M}^{\pm} = \sum_{\mu} D_{M\mu}^{\pm}(\phi, \theta, \psi) \beta_{\mu}^{\pm} \quad (16)$$
The wave functions of the intermediate states in the laboratory frame that have a projection $M$ of the total angular momentum on the $z$ axis can be represented in terms of of wave functions in the intrinsic frame:

$$|1M(K), m > = \sqrt{\frac{3}{8\pi^2}} [\mathcal{D}^1_{M-K}(\phi, \theta, \psi) \mathcal{Q}^\dagger_{m,K}]_{QRPA} > \quad (\text{for } K = 0),$$

$$|1M(K), m > = \sqrt{\frac{3}{16\pi^2}} [\mathcal{D}^1_{MK}(\phi, \theta, \psi) \mathcal{Q}^\dagger_{m,K} + (-1)^{1+K} \mathcal{D}^1_{M-K}(\phi, \theta, \psi) \mathcal{Q}^\dagger_{m,-K}]_{QRPA} > \quad (\text{for } K = \pm 1).$$

The amplitudes of $\beta^-$ and $\beta^+$ from a ground state of initial nucleus to a one phonon state in final nucleus are expressed by

$$< 1(K), m | \hat{\beta}_K^- | 0_{g.s}^+ > = \sum_{ab} N_{a\alpha',b\beta'} F^{1K}_{a\alpha\beta} < a || |b > [u_{\alpha\alpha'} v_{n,\beta\beta'} X_{a\alpha',b\beta',K} + v_{\alpha\alpha'} u_{n,\beta\beta'} Y_{a\alpha',b\beta',K}],$$

where $|0_{g.s}^+ >$ denotes the correlated RPA ground state in the laboratory frame and the normalization factor is given as $N_{a\alpha',b\beta'}(J) = \sqrt{\{1 - \delta_{a\beta} \delta_{a',b'}(-1)^{J+T}/[(1 + \delta_{a\beta} \delta_{a',b'})].}$ This form is easily reduced to the results by pnQRPA without pn pairing

$$< 1(K), m | \hat{\beta}_K^- | 0_{g,s}^+ > = \sum_{a\beta} [u_{a\beta} v_{\beta n} X_{a\beta n,K} + v_{a\beta} u_{\beta n} Y_{a\beta n,K}].$$

3. Results

We calculated the Gamow-Teller strength $B(GT)$ within the DQRPA on $^{26}$Mg and $^{60}$Ni. The single particle states corresponding in the spherical limit are used up to 4$\hbar\omega$ for two nuclei. In this work, the quadrupole deformation parameter $\beta_2$ is chosen by four values, 0.1, 0.25, -0.1, and -0.25, as a default value. For pairing interactions, the renormalizing strengths $g_{pp}$ and $g_{nn}$ are adjusted to reproduce the empirical pairing gaps through a symmetric five term formula. The $\beta_2$ and the gap parameters are listed in Table I. We put the particle-hole(particle-particle) strenghts $g_{ph}(g_{ph}) = 1.0$ for two nuclei. In this work we performed without np-pairing correlation and are in progress with np-pairing correlation at the Deformed BCS.

In Fig. 1, we show that the Gamow-Teller strength in $^{26}$Mg as a function of the excitation energy $E_{ex}$ in the daughter nucleus $^{26}$Al. In the top panel of the left side, the experimental data by $^{26}$Mg(n,p)$^{26}$Al are taken form Ref. [9], where the energies of two dotted lines are not fixed. Other panels of Fig. 1 represents the our calculation values with different $\beta_2$. We show that the position of the excitation energies is reproduced well compared with available experimental data at $\beta_2 = 0.25$. In Fig. 2, We calculated the distribution of $B(GT)$ values in $^{60}$Ni. The top panel of Fig. 2 is the the experimental data by $^{60}$Ni(n,p)$^{60}$Cu at MSU and others are our results of DQRPA. Our results can reproduce the position of the excitation energies at $\beta_2 = 0.1$ but can’t reproduce the the B(GT) strength and ISR compared with available experimental data and other theoretical calculations. Therefore, we are checking to solve some problem for the B(GT) strenght and ISR.

4. Summary and Conclusion

To describe a single particle state in deformed basis, we used the deformed axially symmetric Woods-Saxon potential. We performed the deformed BCS and deformed QRPA with realistic two-body interaction calculated by Brueckner G-matrix based on Bonn potential. Our calculation can reproduce well the position of the excitation energies on $^{26}$Mg and $^{60}$Ni but we have to check some problem which are the B(GT) strength, ISR, and the beta transition operator. Finally, relevant reactions for Pycnoreactions for the superburst and in BCS with np-pairing correlations are in progress.
Table 1. Values of the deformation parameters $\beta_2$, pairing strength parameters $g_{pp}(g_{nn})$ and pairing gap parameters. In the last column ISR denotes the Ikeda sum rule without np-pairing correlation. The particle-particle(particle-hole) strength parameters are $g_{pp} = 1.0 (g_{ph} = 1.0)$ for all nuclei.

| nucleus | $\beta_2$ | $g_{pp}$($g_{nn}$) | $\Delta_p$(MeV) | $\Delta_n$(MeV) | ISR(%) |
|---------|-----------|--------------------|-----------------|-----------------|--------|
| $^{26}$Mg | 0.1       | 1.33(1.25)         | 28.9            |                 | 28.9   |
|         | 0.25      | 1.38(1.25)         | 2.314           | 1.890           | 52.3   |
|         | -0.1      | 1.35(1.10)         |                 |                 | 128.2  |
|         | -0.25     | 1.45(1.19)         |                 |                 | 167.2  |
| $^{60}$Ni | 0.1       | 1.24(1.15)         |                 |                 | 42.7   |
|         | 0.25      | 1.31(1.28)         | 1.664           | 1.538           | 42.1   |
|         | -0.1      | 1.04(1.12)         |                 |                 | 109.3  |

Figure 1. (Color online) Gamow-Teller strength distribution $B(GT)$ in $^{26}$Mg as a function of the excitation energy $E_{ex}$ in the daughter nucleus $^{26}$Al.

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Figure 2. (Color online) The same as in Fig.1, but for \(^{60}\)Ni.

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