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Continuum background in the giant resonance region of excitation

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The moving source model parametrization has been used to explain satisfactorily the continuum background lying under the giant resonances excited through the inelastic scattering of 270 MeV ^{3}He from the targets with A values lying between 58 and 208.

In a typical inelastic scattering spectrum, the giant resonance (GR) appears as a broad bump riding on a large continuum.[1] It is often found that in extracting the strengths of giant resonances (GR) excited through the inelastic scattering of hadrons, the main uncertainty arises from our insufficient knowledge about the shape and the magnitude of the continuum background lying under the GR.[1] Several processes such as quasifree scattering, knockout reaction, pickup-breakup process, higher multipole excitation, and preequilibrium emission are expected to contribute to the continuum background with their relative contributions being dependent on the projectile energy, type, and angle of observation. Even though some progress has been made towards understanding the continuum[2-6] our knowledge about this is rather incomplete. The moving source model[6] (MSM) has been successfully applied to parametrize a large body of particle spectra obtained from both heavy-ion[6] and light-ion[7-9] induced reactions. In the present work we have extended the MSM to parametrize specifically the continuum background subtracted from under the GR, excited through the inelastic scattering of 270 MeV ^{3}He from ^{58}Ni, ^{90}Zr, ^{116}Sn, and ^{208}Pb. The experiment was performed at the Indiana University Cyclotron Facility. The experimental details and the analysis concerning the GR have been reported elsewhere.[10] In the present work we are mainly concerned with the analysis of the continuum background using the MSM parametrization. It is found that the parameters determined are more or less independent of the target, and are in broad agreement with the ones obtained for the projectile-like source.[6,9]

Usually the continuum background lying under the GR is determined phenomenologically by joining smoothly the data points in the excitation region around $E_x \sim 25-30$ MeV (above the high energy octupole resonance) and the ones around $E_x \sim 5-7$ MeV (below the low energy octupole resonance). Even though this procedure is somewhat arbitrary and subjective, it has yielded fairly consistent results for the GR strengths.[1] Various empirical expressions have been tried to describe the continuum background.[10-12] Bonin *et al.*[11] have used the form $\exp(a_1 + a_2\theta + a_3E_x + a_4\theta E_x)$ to fit the continuum alpha spectra spanning a range of θ (scattering angle) and E_x (excitation energy) values with a_1, a_2, a_3, and a_4 as adjustable parameters. McDaniels *et al.*[12] have used the form $b_1\exp[-(E-b_2)^2/b_3]$ to describe the continuum proton energy spectra—with b_1, b_2, and b_3 as parameters. Further the parameter b_3 assumes different values in fitting the proton spectra measured at different θ values. As such this prescription uses more parameters than that of Bonin *et al.*[11] In our earlier work[10] we have shown that the continuum spectra can be adequately represented by an expression of the type $c_1\exp(-c_2\theta)$ with c_1 and c_2 as parameters. It has been found[10] that while the parameter c_2 is less sensitive to the E_x range chosen, the parameter c_1 varies depending on the E_x region fitted. As the MSM parametrization has been fairly successful in describing the smooth energy spectra of particles produced in both light- and heavy-ion induced reactions, we have applied this prescription to explain specifically the continuum background lying under the GR excited through the inelastic scattering of 270 MeV ^{3}He. According to the MSM, during the interaction of the projectile (A_P, Z_P) with the target (A_T, Z_T) a local hot source is formed (more than one source is also possible) and the particle emission (ejectile) is supposed to take place from this moving source. The source is characterized by velocity V_0 and temperature T. The cross section for particle emission in the laboratory system is given as[6]

$$d^2\sigma/d\Omega\, dE = N_0\sqrt{E_s}\exp(-E_S/T)/\sin(\theta)\ , \qquad (1)$$

where

$$E_S = E + E_0 - V_c - 2\sqrt{(E-V_c)E_0}\cos(\theta)\ .$$

Here V_c is the Coulomb correction $Z_PZ_T/(A_P + A_T)$ and N_0 is the normalization factor. Further θ is the scattering angle and E is the energy of the ejectile. $E_0 = 0.5mV_0^2$ where m = mass of ejectile.

The parameters N_0, E_0, and T were varied to obtain the best fit to the continuum helion spectra in the energy region $E = 235$ to 260 MeV and $\theta = 12°$ to 20°. In Figs. 1–4, the MSM fits to the assumed background spectra are shown for ^{58}Ni, ^{90}Zr, ^{116}Sn, and ^{208}Pb targets. The overall quality of the fits can be considered satisfactory.

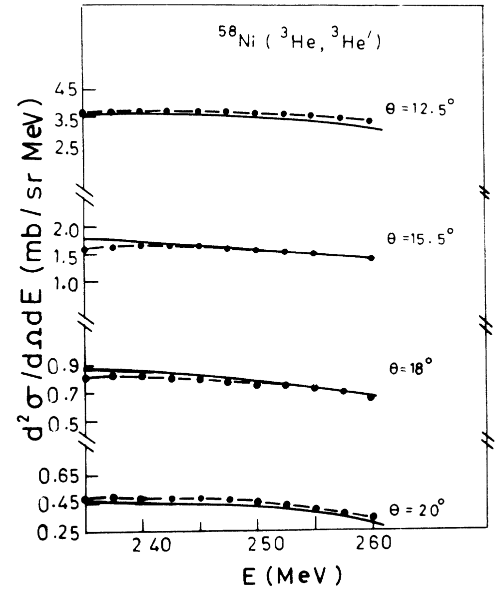

FIG. 1. Inelastic helion spectra from ^{58}Ni target. The dot-dashed lines represent the assumed background subtracted from under the giant resonance. The continuous lines represent the moving source model fits according to Eq. (1). (See text).

The parameters determined are listed in Table I. The parameters E_0 and T are nearly the same for all the targets and this observation is consistent with the results of MSM analysis already reported in the literature.[6] It is not clear at this stage whether this observation is indicative of a common interaction mechanism or is a general feature of MSM parametrization. The values of the pa-

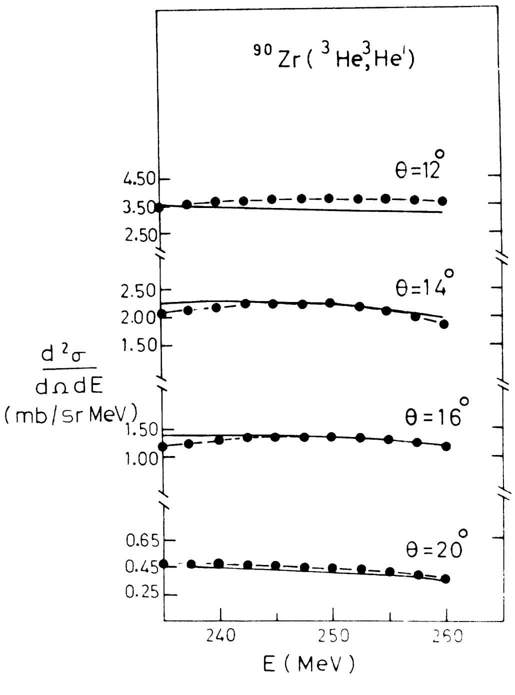

FIG. 2. Inelastic helion spectra from ^{90}Zr target. The dot-dashed lines represent the assumed background subtracted from under the giant resonance. The continuous lines represent the moving source model fits according to Eq. (1). (See text).

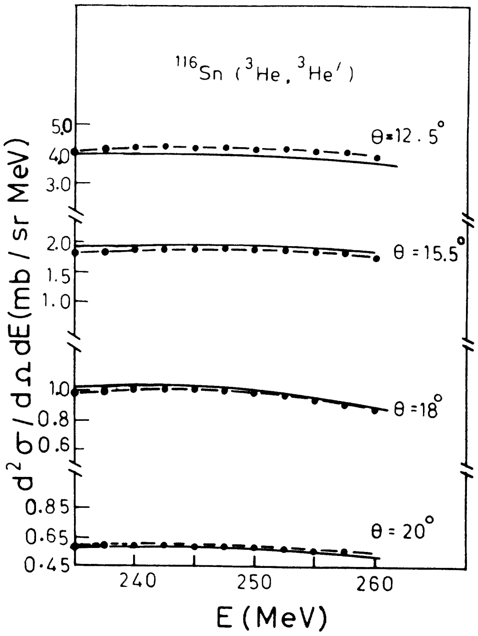

FIG. 3. Inelastic helion spectra from ^{116}Sn target. The dot-dashed lines represent the assumed background subtracted from under the giant resonance. The continuous lines represent the moving source model fits according to Eq. (1). (See text).

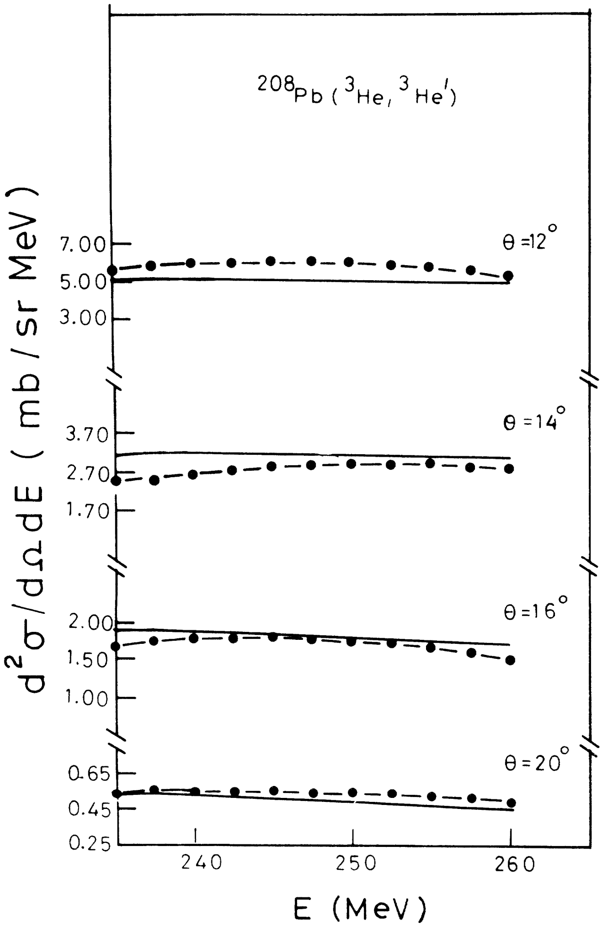

FIG. 4. Inelastic helion spectra from ^{208}Pb target. The dot-dashed lines represent the assumed background subtracted from under the giant resonance. The continuous lines represent the moving source model fits according to Eq. (1). (See text).

TABLE I. Results from moving source model analysis. N_0 in mb/sr MeV$^{3/2}$; E_0 in MeV; T in MeV.

Targets	^{58}Ni	^{90}Zr	^{116}Sn	^{208}Pb
N_0	0.99±0.06	0.75±0.04	0.92±0.04	1.2±0.1
E_0	206±7	215±8	222±8	226±17
T	7.8±0.2	8.3±0.3	8.5±0.3	7.6±0.4

rameter T are in good agreement with the ones obtained for the projectile-like source.[6,9] This is consistent with the expectation that the spectra in the forward angular range are dominated by contributions from the projectile-like source.

In conclusion we have shown that the continuum background spanning a range of θ of E can be explained well by a simple three parameter moving source model (MSM) parametrization. We have found that the parameters determined are not strongly dependent on the target mass number. It may be pointed out that the number of parameters used in the present prescription is less compared to the ones employed in the other empirical expressions.[11,12] The smooth shape normally assumed for the background continuum can be justified in terms of the MSM parametrization. Even though we cannot calculate *a priori* the continuum background in view of the overall normalization factor involved in the MSM parametrization, the usefulness of this parametrization can be to fix the overall shape of the background with the form given by the MSM.

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