Lifetime Studies of Compound Nuclei in the "Statistical" Continuum

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We have used the crystal-blocking technique to study changes in compound-nuclear lifetimes produced by changes in continuum conditions (proton bombarding energy) or in detected outgoing proton energies in inelastic scattering.[1]

The enhancement effect of an isobaric analog resonance on the underlying Coulomb-admixed fine structure was demonstrated,[2] as well as the difference in arrival times of shape-elastic (prompt) and compound-elastic protons.[3] Sub-micron-thick single-crystal targets of Ge and Ni, as well as both one- and two-dimensional[4] position-sensitive detectors allowed us to observe axial blocking patterns efficiently.

Concentrating on the case of Ni,[5] thin- (evaporated) target elastic and inelastic scattering excitation curves show fluctuations (Fig. 1) which we showed not to be normal Ericson fluctuations since the extracted coherence widths ($\sim$10 keV) exceeded by at least two orders of magnitude the mean widths inferred from our lifetime determinations. We believe that the fluctuations are in fact Ericson fluctuations of $T_>$ (analog) states whose density and widths in the rather special case of Ni + p are of the right order at these excitation energies ($\sim$10 MeV).

For the case of elastic proton scattering we were able to extract both the fraction of compound-elastic contribution and its lifetime (Table I), using an elaborate charged-particle penetration code[6,7] for matching the experimental blocking dips (Fig. 2). Moreover, we were able to set the limits on the deviation from exponential decay of compound-elastic scattering at the 10^{-17}-second level. (Cf. Table I.) An interesting difference in lifetimes can be seen at two neighboring excitation energies for ^{59}Cu, showing indications of non-statistical (intermediate structure) effects in the continuum.

I wish to acknowledge the many contributions to this work by my colleagues as well as the support of the N.S.F.

References

[1]See e.g. W. M. Gibson, Ann. Rev. Nucl. Sci. 25, 465 (1975).
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[3]E. P. Kanter et al., Phys. Rev. Lett. 35, 1326 (1975).
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[5]E. P. Kanter et al., Nucl. Phys. A299, 230 (1978).
[6]Y. Hashimoto et al., Phys. Rev. Lett. 30, 995 (1973).
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TABLE I. Results of decay probability fits for Ni(p,po). f_{SE} = shape-elastic fraction; τ in units of 10^{-18} sec is the extracted lifetime; β in units of 10^{18} sec^{-1} gives non-exponential decay component.

E_p (MeV)	f_{SE} (%)	τ (as)	β (as^{-1})
5.65	80.3 ± 2.4	43.9 ± 1.9	1.9 ± 3.0
6.50	76.8 ± 4.2	63.0 ± 3.9	0.5 ± 3.3

$$F(t) = f_{SE}\delta(t) + \frac{(1-f_{SE})e^{-t/\tau}(1+\beta t+\gamma t^2+\ldots)}{\int e^{-t/\tau}(1+\beta t+\gamma t^2+\ldots)}$$

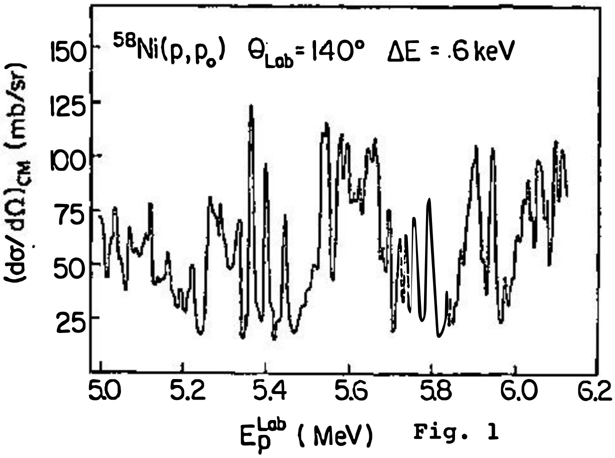

Fig. 1

Figure Captions:

Fig. 1. Thin-target excitation function for ^{58}Ni(p,po) at 140°, between 5.0 and 6.2 MeV.

Fig. 2. Fits to circular scans of two-dimensional blocking data at 140°. $f_{CE} \equiv 1 - f_{SE}$. MS-SE = Multiple-String-Statistical Equilibrium calculations (Ref. 7). Recoil reflects lifetime. (a) E_p = 5.65 MeV; (b) E_p = 6.50 MeV.

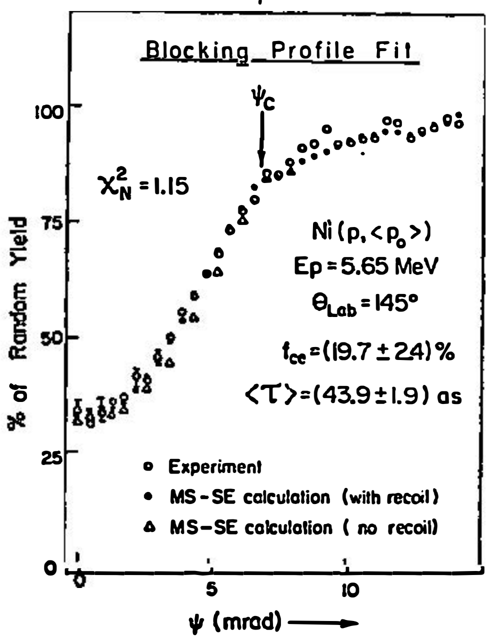

Fig. 2

(a)

(b)