Mechanism of the $^{12}C(^{6}Li, d)^{16}O$ Reaction Leading to the 6.92- and 7.12-MeV Levels of ^{16}O†

Clyde S. Zaidins
Nuclear Physics Laboratory, Department of Physics and Astrophysics, University of Colorado, Boulder, Colorado 80302
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The contributions of compound-nuclear and direct processes to the $^{12}C(^{6}Li, d)^{16}O$ 6.92- and 7.12-MeV levels at two c.m. energies are discussed.

In a recent paper,[1] Carlson, utilizing the angular distributions of deexcitation γ rays following the $^{12}C(^{6}Li, d)^{16}O$ reaction, concluded that the 6.92-MeV level of ^{16}O is produced by a direct reaction, whereas the 7.12-MeV level is not. The purpose of this note is to point out the relationship between the results of this excellent experiment in the sub-Coulomb region from 3.0 to 4.3 MeV to those in an earlier study[2] at a c.m. energy of 7 MeV.

The amplitude of a direct reaction leading to states in ^{16}O, which is most readily looked at as an α-transfer reaction when ^{12}C is one of the nuclei in the entrance channel, is related to the α width of the ^{16}O state involved. The reactions $(^{7}Li, t)$[3] and $(^{12}C, ^{8}Be)$,[4] as well as $(^{6}Li, d)$[1,2] show a much higher cross section for the 6.92-MeV level than for the 7.12-MeV level. The conclusions that are drawn from those experiments and other considerations are that the 6.92-MeV level (2^+) has a large 4p-4h configuration and a reasonable α width, whereas the 7.12-MeV level (1^-) has 1p-1h plus 3p-3h configuration and an α width probably 2 to 5 times smaller than that for the 6.92-MeV level.

The data of Loebenstein *et al.*[2] at a c.m. energy of 7 MeV was analyzed in terms of a compound-nuclear plus α-transfer mechanism in the $^{6}Li(^{12}C, d)^{16}O$ reaction. At this higher energy approximately 50% of the 6.92-MeV level formation was by a compound-nuclear process, whereas a larger percentage of the 7.12-MeV level formation was by a compound-nuclear process. The energies measured by Carlson were chosen to optimize the direct to compound-nuclear contributions. Although the uncertainties are too large to warrant a numerical extrapolation from 7 to 4.3 MeV and below, the following might be expected to occur. The compound-nuclear contribution to the 6.92-MeV level could fall below about 25% which appears to be consistent with Carlson's data, while possibly remaining large (> 50%) for the 7.12-MeV level. This could explain both the nature of the data fits for the 6.92- and 7.12-MeV levels shown by Carlson, and the relative γ yields from the two levels. This ratio of $4\frac{1}{2}$ in favor of the 6.92 level yield could be explained by direct-reaction ratio of 5 for the 6.92- to 7.12-MeV levels with the approximate contributions of direct reaction as 75% for the 6.92-MeV and 50% for the 7.12-MeV level. It would be very useful if a quantitative measure of the direct-reaction contribution to these two levels could be deduced as a function of energy as this would increase the confidence in the extracted reduced α width for the two levels. These α-width parameters are important in both nuclear structure studies and in the astrophysical reaction $^{12}C(\alpha, \gamma)^{16}O$.

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