Proton elastic scattering by deuterium
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This account adds to the assessment already given by Shi Liqun.

Experimental studies on the proton – deuteron system have been published in a number of articles. EXFOR presents data from at least 45 publications. Both particles have been used as projectiles, proton scattering by deuterium and deuteron scattering by hydrogen have been measured. Again, in the case of incident deuterons, both scattered deuterons as well as recoiled protons have been detected in the experiments.

Many of the experiments are of limited interest from the point of view of ion backscattering analysis, due to their high energy or because data are presented as angular distributions or the data have been taken for small scattering angles. There are, however, several publications which are potentially useful to ion beam applications. At least 14 publications present relevant cross sections for more than one energy value[1 - 14].

There has been an unfortunate controversy in the data given by Langley [9]. The discrepancy between his two sets of values is related to the conversion between the center-of-mass (CM) and laboratory coordinates and between absolute cross sections (in b/sr) and relative cross sections (cross section/Rutherford cross section). Langley presents the same data in mb/sr in the CM-system and as relative cross sections in the laboratory system (the relative cross section is the same for both reference systems). The cross sections derived from these two data sets differ by about a factor of 4. The scattering angles are also inconsistent. The controversy has been discussed, e.g., by M. Mayer on the SIMNRA website [15].

In IBANDL, the set of relative cross section data has been adopted as referring to a laboratory scattering angle of 151°. This is the similar to the figure in the Ion Beam Materials Analysis Handbook [16]. SIMNRA suggests that the cross sections calculated from the absolute values by Langley (HD165_Langley.r33 in SIMNRA) should be adopted for the laboratory scattering angle of 165° (165° CM-angle equals to 151° laboratory angle). These absolute data by Langley are also shown as Fig. 2.2 by Shi Liqun in his assessment for this CRP (172.5° CM-angle equals to 165.1° lab angle).

Further support for the cross sections calculated from the absolute values by Langley at the laboratory angle of 165° may be gained from comparison with other published values. Converting the CM-cross sections and CM-scattering angles to the laboratory system, one finds that there is a good agreement with the Langley absolute values and those of Kocher and Clegg. Kocher and Clegg quote uncertainties of the order of 1% or less for their data. Furthermore, they claim a good agreement between their data and those of Refs. [2, 5, 6 and 10]. These studies quote larger uncertainties, of the order of 2-5 %. A comparison of cross sections for scattering angles above 125° from various publications is presented in Fig. 1.

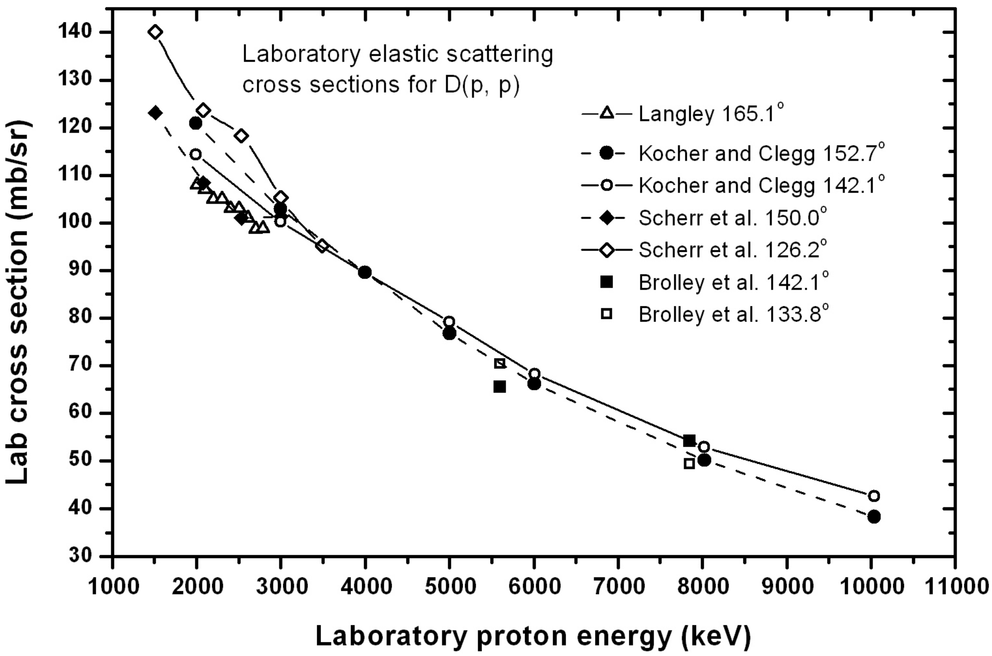

Fig. 1. Elastic scattering cross sections for D(p, p) in the laboratory system for the Langley absolute data, for Kocher and Clegg, Scherr et al. and Brolley et al. The scattering angles refer to the laboratory frame of reference (the Langley data approximately digitized from a graph).

It must thus be concluded that of the two Langley data sets, the one based on the relative values at 151° laboratory angle is incorrect. As long as no further data are available, the suggested cross sections for use in large angle backscattering analysis are those of Kocher and Clegg and the data set based on the absolute values by Langley. The two most recent publications, by Lahlou et al. [13] and Huttel et al. [14], present a few cross sections data points between 3.1 and 3.7 MeV and between 0.4 and 1.0 MeV for angles below 135°. These data are also in qualitative agreement with the earlier data.

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