Suppression of the Coulomb interaction in the off-energy-shell p − p scattering from the p + d → p + p + n reaction

A. M. Mukhamedzhanov, A. Tumino,[1] C. Spitaleri,[1] G. G. Rapisarda,[1] S. Cherubini,[1] V. Crucillá,[1] M. Gulino,[1] M. La Cognata,[1] L. Lamia,[1] F. Mudó,[1] R. G. Pizzone,[1] S. Romano,[1] M. L. Sergi,[1] Z. Elekes,[2] Z. Fülöp,[2] G. Gyürky,[2] G. Kiss,[2] and E. Somorjai[2]

[1]*Dipartimento di Metodologie Fisiche e Chimiche per l'Ingegneria - Universitá di Catania, Catania and Laboratori Nazionali del Sud - INFN, Catania, Italy*,

[2]*ATOMKI - Debrecen, Hungary*

The proton-proton scattering has been extensively investigated in the past in order to gather more information on the nuclear force. Despite the simplicity of the p+p system, the analysis of such interaction is complicated by the presence of the Coulomb scattering that has to be considered in addition to the nuclear effects. There is a region at low p+p relative energy (*Epp*) in which the nuclear scattering amplitude in the 1S-state and the even part of the Coulomb scattering amplitude give destructive interference [1], leading to the deep minimum in the p+p cross section.

Such a strong signature has recently triggered the idea that an indirect study of the p−p scattering at low energy can provide another important test for the Trojan Horse Method (THM). Indeed the interference pattern should be missing if there is no sizeable Coulomb amplitude, and this is what the THM is for. In the present we address the study of the p+p elastic scattering through the $^2H(p,pp)n$ reaction. The aim of the experiment is to investigate the suppression of the Coulomb amplitude also for scattering. This will be done by checking whether there is still evidence of the nuclear plus Coulomb interference pattern in the half-off-energy-shell (HOES) p+p cross-section extracted via the THM. This experimental cross-section will be compared with the calculated HOES one and with the on-energy-shell (OES) counterpart in the energy region where the Coulomb-nuclear interference occurs. We note that in the case of elastic scattering, the off-shell suppression mechanism of the Coulomb interaction is quite different from that of rearrangement reactions mentioned before. In particular, in the case of elastic scattering the total amplitude is given by the sum of Coulomb and Coulomb-modified nuclear parts. As we will show, the off-shell effects make the Coulomb amplitude suppressed compared to the nuclear part and the Gamow factor missing in the Coulomb modified nuclear amplitude. Thus leads to an additional enhancement of the nuclear scattering. The low energy $^2H(p,pp)n$ reaction in the QF kinematics was measured several times before (see [2] and references therein), but not in the region where the p−p Coulomb-nuclear interference takes place. We made the first measurements of this reaction at 5 MeV of beam energy in the interference region at the ATOMKI, Debrecen (Hungary). In Fig. 1 we present the HOES p+p extracted from the measured $^2H(p,pp)n$ reaction (black full dots from present work, red triangles and blue stars from our previous measurements [2,3]) compared with the theoretical OES p+p cross section (black solid line); dashed-dotted line is the HOES p+p cross section calculated using the HOES Coulomb scattering amplitude and HOES Coulomb-modified nuclear scattering amplitude generated by the Yamaguchi potential. We observe a striking disagreement between the THM (HOES) and free p+p (OES) cross sections throughout the region of the interference minimum, which is missing in

the THM data. Instead, the calculated HOES p+p cross section nicely fits the THM data. The reason for such a big difference in the energy dependence between low-energy OES and HOES cross sections is due to the suppression of the HOES Coulomb scattering amplitude. Due to this suppression the energy dependence of the HOES cross section is very similar to the energy dependence of the OES n+n and p+n cross sections. The effect of the suppression of the Coulomb effects is universal whether we consider reaction or scattering what provides another validation of the THM. The paper has been accepted for publication in Physical Review Letter (2007).

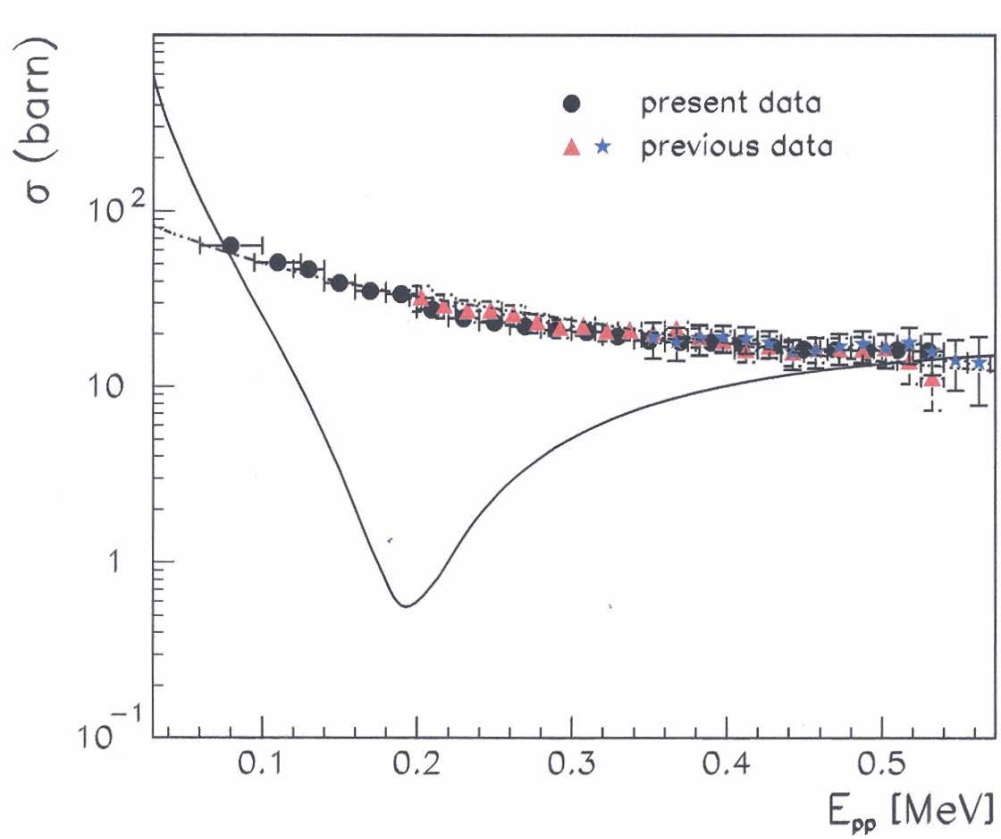

Figure 1. Red diamonds are the OES experimental *p-p* cross section [1] and black full dots are the THM *p-p* cross sections (from the present experimental work; red triangles and blue stars are our data from Ref. [3]. Solid line represents the theoretical OES *p-p* cross section and the dashed-dotted line is the HEOS *p-p* cross section calculated as explained in the text.

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