Microscopic coupled-channels calculations of nucleus-nucleus scattering including chiral three-nucleon-force effects

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The microscopic description of nuclear reactions is an important subject in nuclear physics. Recently, the Melbourne group achieved a great success by describing proton scattering with no adjustable parameter. They applied a g-matrix interaction constructed with the Bonn potential to the folding model calculation, and reproduced the measured elastic cross sections and analyzing powers in a wide incident-energy range [1].

In spite of the remarkable progress of microscopic reaction theory in recent years, however, nucleus-nucleus elastic cross sections cannot be well reproduced in some cases [2]. One of the reasons for this failure may be the lack of three-nucleon force (3NF) effects in nucleus-nucleus scattering; the Melbourne interaction does not include the effects explicitly. In addition, strong coupled-channels effects coming from mutual excitations are expected for nucleus-nucleus scattering. We should consider the 3NF and coupled-channels effects together for nucleus-nucleus scattering.

In this work, we analyze ^{16}O-^{16}O and ^{12}C-^{12}C scattering with the microscopic coupled-channels method including chiral 3NF effects, and investigate the coupled-channels and three-nucleon-force (3NF) effects on elastic and inelastic cross sections. In the microscopic coupled-channels calculation, the Melbourne g-matrix interaction modified according to the chiral 3NF effects is used.

In Fig. 1, we show the elastic and inelastic differential cross sections for ^{16}O-^{16}O scattering at 70 MeV/nucleon and ^{12}C-^{12}C scattering at 85 MeV/nucleon. It is found that the coupled-channels and 3NF effects additively change both the elastic and inelastic cross sections. As a result, the coupled-channels calculation including the 3NF effects significantly improves the agreement between the theoretical results and the experimental data. As a general tendency, we can say that the 3NF (coupled-channels) effects are important at relatively high (low) incident energies and at large (small) scattering angles. This is understood by the fact that the 3NF effects strongly affects the interior part of the nucleus-nucleus potential, whereas the coupled-channels effects affect the surface part of it.

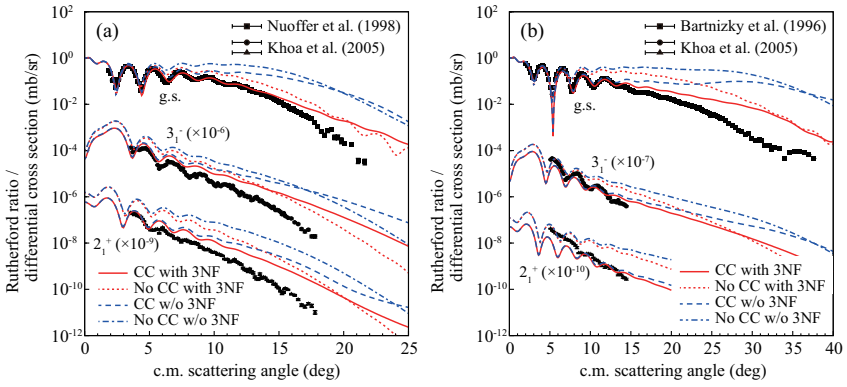

Figure 1: Elastic and inelastic differential cross sections for (a) ^{16}O-^{16}O scattering at 70 MeV/nucleon and (b) ^{12}C-^{12}C scattering at 85 MeV/nucleon. These figures are taken from Ref. [3].

The coupled-channels calculation including the 3NF effects significantly improves the agreement between the theoretical results and the experimental data. However, there remain some discrepancies between them, at backward angles in particular. It will be important to perform coupled- channels calculations including even higher excited states. This work was published in Physical Review C [3].

References

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