Off-Shell Behaviour of the Nucleon-Nucleon Interaction.

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Summary. — We investigate the off-shell behaviour of the nucleon-nucleon interaction by means of Noyes-Kowalski half-off-shell functions and bound-state (deuteron) as well as nucleon-nucleon scattering wave functions. The models for the nucleon-nucleon interaction, we consider, are the meson-theoretical Paris potential together with separable representations of its on-shell and off-shell behaviour (PEST potentials). We contrast them to the Afnan-Clement-Serduke potential, as an example of purely phenomenological separable potentials. Important implications for few-body problems like electron-deuteron and nucleon-deuteron elastic scattering are discussed.

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1. – Introduction.

Due to the increasing amount of experimental data accumulated over recent years, the on-shell nucleon-nucleon (N-N) interaction has become rather well constrained up to laboratory kinetic energies of \( E_{\text{lab}} \approx 500 \text{ MeV} \). Nowadays, one finds the most elaborate N-N force models \(^{(1-4)}\) to agree rea-
reasonably well with predictions of modern phase shift analyses (5-7); likewise the static properties of the deuteron can be reproduced in a satisfactory manner. As a consequence, we may consider the problem of the on-shell $N^*-N$ interaction as suitably settled, notwithstanding a few subtle questions, which are still open, like charge (a) symmetry or the determination of the $^3S_1-^3D_1$ mixing parameter $\varepsilon_3$ at low energies, to mention only two of them.

With regard to the off-shell behaviour of the $N^*-N$ interaction, the situation is completely different. From the theoretical side, various force models, similar in their on-shell properties, may show diverse off-shell characteristics. To a large extent, this is even true within a class of interactions derived from the same dynamical principle, meson exchange, say. The first, and in fact the most prominent place, in which such differences can be observed, are deuteron wave functions and consequently electromagnetic form factors, but also scattering wave functions, etc.

Yet, it is from the side of few-body experiments that the off-shell $N^*-N$ interaction has recently received renewed interest. In general, polarization observables of few-body scattering processes, like electron-deuteron (e-d), nucleon-deuteron ($N$-d), pion-deuteron ($\pi$-d) and so on, have been found to be fairly sensitive on the $N^*-N$ off-shell behaviour (8-11). Consequently, they can be expected to pin down the existing off-shell arbitrariness. At first, it is important to disqualify grossly unrealistic off-shell properties often shown by purely phenomenological models, e.g., former separable potentials (12). Further on, these processes can be used to classify several dynamical assumptions about the $N^*-N$ force, like meson exchange, bag models, quark-gluon exchange and so forth. Finally, such observables, if measured to great accuracy, could be selective enough to distinguish between models belonging to the same dynamical class but differing in their off-shell behaviour through their method of derivation.