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Watson K M. The effect of final state interactions on reaction cross sections. *Phys. Rev.* **88**:1163-71, 1952.
[Physics Department, Indiana University, Bloomington, IN]

Particles produced in a reaction often interact strongly with each other before getting outside the range of their mutual forces. Implications are studied and it is shown that the effect for very strong attractive interactions can be calculated without detailed knowledge of the reaction properties. [The *SCI*® indicates that this paper has been cited in over 435 publications since 1955.]

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This paper was written shortly after I had completed a postdoctoral fellowship at Berkeley. This was an exciting period in the development of elementary particle physics. Both pi- and mu-mesons had recently been discovered. Artificial pi-mesons were being produced in sufficient quantity to do a variety of experiments. The Berkeley 184-inch cyclotron was new and being used to study pi-meson production and annihilation. The Berkeley electron symbotron was producing pi-mesons by photon processes. The Bevatron was under construction. This was shortly to lead to the creation of anti-protons and anti-neutrons. In addition to the vigorous experimental programs, the theoretical group led by Robert Serber was very active.

The production of mesons in nucleon-nucleon collisions[1] showed a distortion in the meson spectrum that was interpreted by Brueckner and me[2] as due to a scattering of the two nucleons after the meson is produced. Also, the capture of pi-minus mesons in deuterium[3] led to a peaking of the γ-ray spectrum. This was interpreted as due to the neutron-neutron force following absorption of the meson.[4]

These experiments suggested to me that there was a general and rather simple phenomenon involved. A strong attractive interaction between two particles can markedly influence the energy and angular distribution of the produced particles. For an impulsive production process, this may be expressible in terms of the scattering of the interacting particle pair. This scattering can be determined in separate scattering experiments.

The general theory of this was developed in my paper. Although specific applications had been developed by Brueckner, Stuart, and me,[2,4] it seemed clear that there were very general phenomena involved. These did not seem dependent on the details of the interactions, but principally on the kinematics of the incoming and outgoing particles and on their pairwise scattering cross sections. Conditions of validity were determined for this theory. Time-reversal invariance for strong interactions led also to the applicability for a class of particle annihilation phenomena.

The simplicity of the result and the range of phenomena to which it has been applicable seem to have made it quite useful. It has permitted scattering experiments to be used in predicting other experiments that lead to new particle creation. Perhaps, more significantly, it has permitted de-convolving the effects of final particle interactions to study the mechanisms of particle production.

This theory has had application to a variety of reactions in molecular, nuclear, and elementary particle physics. (For a recent review see, for example, reference 5.)

1. **Cartwright W F, Richman C, Whitehead M N & Wilcox H A.** The production of π^+-mesons by protons on protons in the direction of the beam. *Phys. Rev.* 78:823-4. 1950. (Cited 1 time since 1955.)
2. **Watson K M & Brueckner K A.** The analysis of π-meson production in nucleon-nucleon collisions. *Phys. Rev.* 83:1-9. 1951. (Cited 35 times since 1955.)
3. **Panofsky W K H, Aamodt R L & Hadley J.** The gamma-ray spectrum resulting from capture of negative π-mesons in hydrogen and deuterium. *Phys. Rev.* 81:565-74. 1951. (Cited 95 times since 1955.)
4. **Watson K M & Stuart R N.** On the γ-ray spectrum resulting from the absorption of π-mesons in deuterium. *Phys. Rev.* 82:738-44. 1951. (Cited 35 times since 1955.)
5. **Joachain C J.** Two-potential scattering. *Quantum collision theory.* Amsterdam: North-Holland. 1975. p. 442-51.

