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Amplitudes for Monopoles

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On-shell methods are particularly suited for exploring the scattering of electrically and magnetically charged objects, for which there is no local and Lorentz invariant Lagrangian description. In this paper we show how to construct a Lorentz-invariant S-matrix for the scattering of electrically and magnetically charged particles. A key ingredient is a revision of our fundamental understanding of multi-particle representations of the Poincaré group. Surprisingly, the asymptotic states for electric-magnetic scattering transform with an additional little group phase, associated with pairs of electrically and magnetically charged particles. The corresponding "pairwise helicity"is identified with the quantized "cross product"of charges, e1g2 – e2g1, for every charge-monopole pair, and represents the extra angular momentum stored in the asymptotic electromagnetic field. We define a new kind of pairwise spinor-helicity variable, which serves as an additional building block for electric-magnetic scattering amplitudes. We then construct the most general 3-point S-matrix elements, as well as the full partial wave decomposition for the $2 \longrightarrow 2$ fermion-monopole S-matrix. In particular, we derive the famous helicity flip in the lowest partial wave as a simple consequence of a generalized spin-helicity selection rule, as well as the full angular dependence for the higher partial waves. Our construction provides a significant new achievement for the on-shell program, succeeding where the Lagrangian description has so far failed.

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