This Week's Citation Classic™ CC/NUMBER 48 NOVEMBER 26, 1984

Freund P G O. Finite-energy sum rules and bootstraps.
Phys. Rev. Lett. **20**:235-7, 1968.
[Enrico Fermi Institute for Nuclear Studies and Department of Physics, University of Chicago, IL]

A local formulation of duality is given. It is conjectured that unlike ordinary Regge exchanges, diffractive Pomeranchuk exchange is dual to nonresonant s-channel background. [The *SCI*® indicates that this paper has been cited in over 375 publications since 1968.]

Peter G.O. Freund
Enrico Fermi Institute
and
Department of Physics
University of Chicago
Chicago, IL 60637

April 13, 1984

"Once upon a time, a theory of strong interactions was not yet available (yes, there was such a time). The many hadrons discovered in experiments could not be elementary, that much was clear. Still, years after the proposals of quarks and color, much of the thinking was phrased in terms of a 'bootstrap scheme': two hadrons would exchange hadrons and due to the resulting force they would bind or resonate into a hadron.

"In 1967, that is, the time I had in mind, Murray Gell-Mann, during a visit to Chicago, brought along a new idea of Dolen, Horn, and Schmid,[1] all of them then at the California Institute of Technology. According to this idea, now commonly referred to as 'duality,' hadron formation and hadron exchange are really the same thing in a technically well-defined way. Always keen on geographical detail, Murray impressed upon us that Chris Schmid was the first (or did he say the only) theoretical physicist from the Aargau (or did he say Thurgau) canton of Switzerland. While pleased to learn that yet another Swiss canton was now represented in theoretical physics, at first I had some misgivings about this idea in view of the fact that 'exotic' combinations of two hadrons such as, say, two positive pions, or K^+p,... were known not to resonate. Yet even in these cases, diffractive scattering was known to take place via 'Pomeranchuk exchange.' So I conjectured that diffractive Pomeranchuk exchange is not responsible for hadron formation but rather it always matches the nonresonant background part of the scattering (again, in a well-defined technical sense). In πn scattering this conjecture led me to a derivation of experimentally successful 'exchange degeneracy' relations. I mentioned K^+p scattering in the last footnote, but did not discuss that case in any detail. Haim Harari[2] then gave beautiful extensive tests of this conjecture for meson-baryon and baryon-baryon scattering. Two-component duality,[1] as duality augmented by the conjecture came to be known, provides a simple, successful, and quite comprehensive picture of high-energy hadronic reactions at fixed momentum transfer (via the optical theorem, this includes total cross-sections). Given the vast body of experiments on such reactions, and the role they have played in sorting out our ideas on strong interactions, one can easily understand the popularity enjoyed by two-component duality.[3] On the theoretical side, dual string theory[4] embodies these ideas in a particularly elegant way. The Pomeron, or glueball, is represented there by a closed string with quarks and antiquarks at their ends, which stand for mesons and baryons.

"Rereading my paper, I couldn't help but be reminded of the fact that most of it is dedicated to a local formulation of duality in the context of a now obsolete 'bootstrap' calculation, and the conjecture is not introduced until the very end with part of it in a 'note added in proof.' (Incidentally, *Physical Review Letters* never sent proofs.) This is partly explained by the fact that I considered the conjecture 'obvious.' I have since learned that the obvious can often be of great importance since it is subjective: what is obvious to someone may not be so to others. One can be blinded by the very light one sees. It is this gauging of one's ideas that I find one of the hardest tasks in science, and I would not be surprised if this were the case in other fields as well."

1. **Dolen R, Horn D & Schmid C.** Prediction of Regge parameters of ϱ poles from low energy data. *Phys. Rev. Lett.* **19**:402-7, 1967. (Cited 155 times.)
2. **Harari H.** Pomeranchuk trajectory and its relation to low-energy scattering amplitudes. *Phys. Rev. Lett.* **20**:1395-8, 1968. (Cited 470 times.)
3. **Fukugita M & Igi K.** Phenomenological duality. *Phys. Rep. C* **31**:237-338, 1977. (Cited 40 times.)
4. **Jacob M, ed.** *Dual theory*. Amsterdam: North-Holland. 1974. 398 p.

