

Serpukhov Data Are Highlight at Regge-Pole Conference

Interest at a recent Regge-pole conference appeared to center on the total cross-section data from the Serpukhov accelerator, Regge cuts, duality and multiparticle production. Substantial progress has been made in Regge-pole models in the past year, and 170 people gathered at the conference, which took place at the University of California, Irvine, on 5 and 6 Dec., to assess the present situation and establish the direction for future progress. (For some understanding of Regge-pole theory and its applications to high-energy physics, see the article by Gerald Hite in *Rev. Mod. Phys.* **41**, 669, 1969.) Summary talks covered the experimental situation, phenomenological analyses and theoretical models; this program was preceded by a session of contributed papers.

The contributed-papers session started with two experimental talks: Paul N. Kirk presented the results of an Argonne National Laboratory-University of Michigan collaboration on the differential cross section for $\pi^+ p \rightarrow K^+ + \Sigma^+$ and the polarization of the Σ^+ at 3 and 5 GeV; D. Hywel White (Cornell University) reported on a measurement of $\pi^- p \rightarrow n \pi^0$ at 6 GeV in the back-scattering region.

Robert Carlitz (California Institute of Technology) showed that if one treated the angular momentum con-

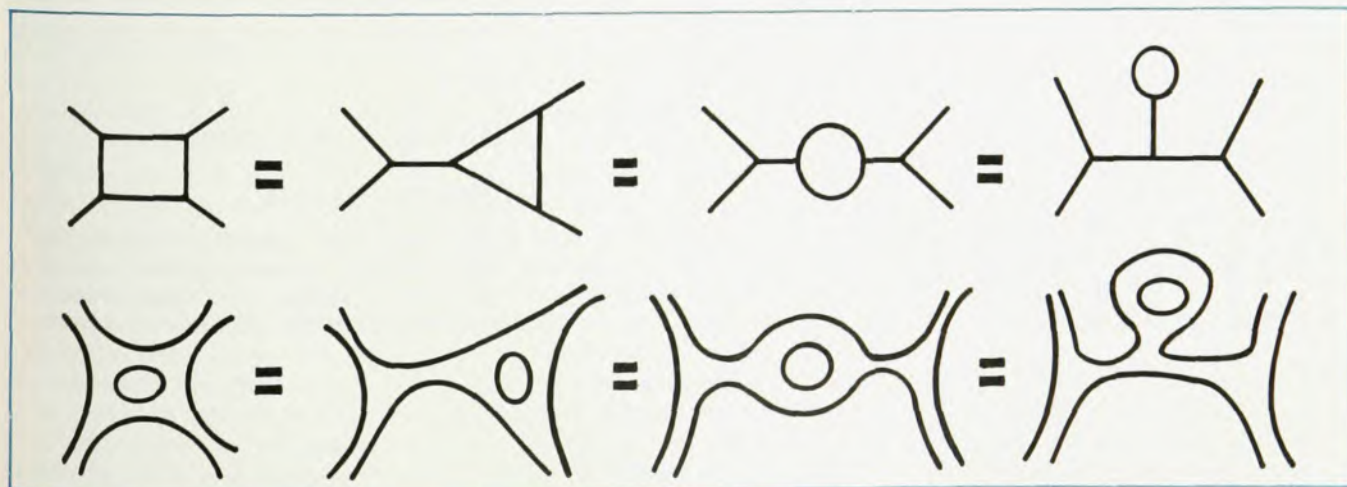
tinuation of a sequence of positive-parity fermion resonances as is done in the van Hove model, these resonances could appear without the negative-parity doubling states at the expense of a fixed cut in the J plane. Rudolph C. Hwa (State University of New York, Stony Brook) considered a bootstrap model of the Pomeron in which the inelastic processes are dominated by diffractive fragmentation as given by the Yang model. Alberto Pignotti (University of Washington, Seattle) presented a method of generating Regge cuts with full connected unitarity that agrees with the absorption-model cut corrections to Regge-pole exchange.

Serpukhov. Three talks covered data from the 76-GeV accelerator at Serpukhov, USSR, on the flattening off of total cross sections. Nathan Dean (Vanderbilt University) showed that his earlier calculations of π -N total cross sections from a multiple-scattering quark model agreed with the Serpukhov data. (The multiple-scattering model could be considered as a prescription for introducing cuts.) According to Frank Steiner (Karlsruhe) the Serpukhov data imply that the isospin-even π -N forward amplitude does not behave at infinity like a simple Regge pole (presumably a cut or "dipole" behavior, as discussed later by Vernon Barger, of the University of Wisconsin, would satisfy the disper-

sion relation). David Horn (Cal Tech) explored the interesting possibility that the conventional Regge expansions and the Pomanchuk theorem fail above 30 GeV. (The ratio of the real to imaginary parts of the forward-scattering amplitudes must then increase as $\log E$. See Richard Eden, *High Energy Collisions of Elementary Particles*, Cambridge U.P., 1968.)

Douglas R. Morrison (CERN) reviewed the experimental results of two-body production processes; the vast amount of data and the accuracy of some of the results is very impressive. He covered the presence and movement of peaks and dips in detail, and discussed tests of duality. Morrison presented the Serpukhov data on $\pi^- p$, $\pi^- n$, $K^- p$, $K^- n$, pp and pn total cross sections from 20 GeV to 65 GeV; they are essentially flat above 30 GeV. The Regge-pole analyses made at lower energies do not, of course, fit the data when extrapolated to these energies. Morrison then commented that, historically, Regge-pole analyses, when applied to known experimental results or interpolated between known data, have been successful. Extrapolation or application to new processes however, has very often been unsuccessful.

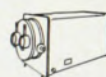
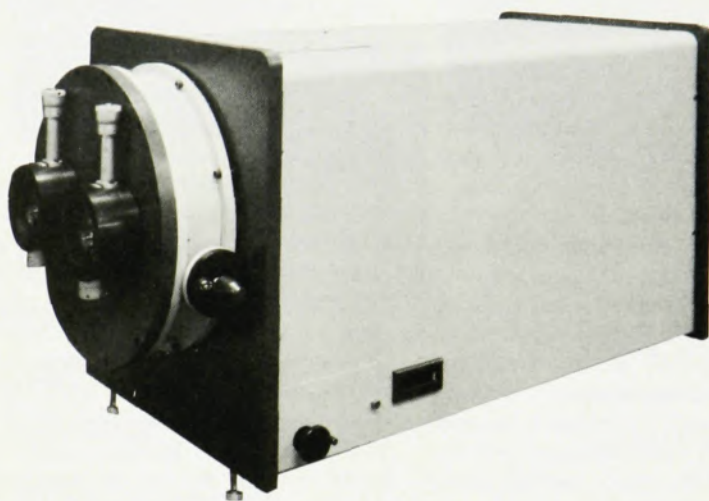
Barger summarized the Regge analysis of high-energy two-body processes. Despite the great success of



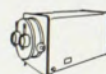
PROGRESS OF THE QUARK, as described by Claude Lovelace: "The quark loop moves along inside like the boa constrictor's lunch, so that a meson box turns into a vertex part, then into a self-energy part, and finally to a tadpole."

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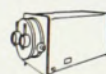
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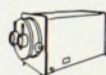
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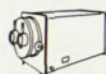
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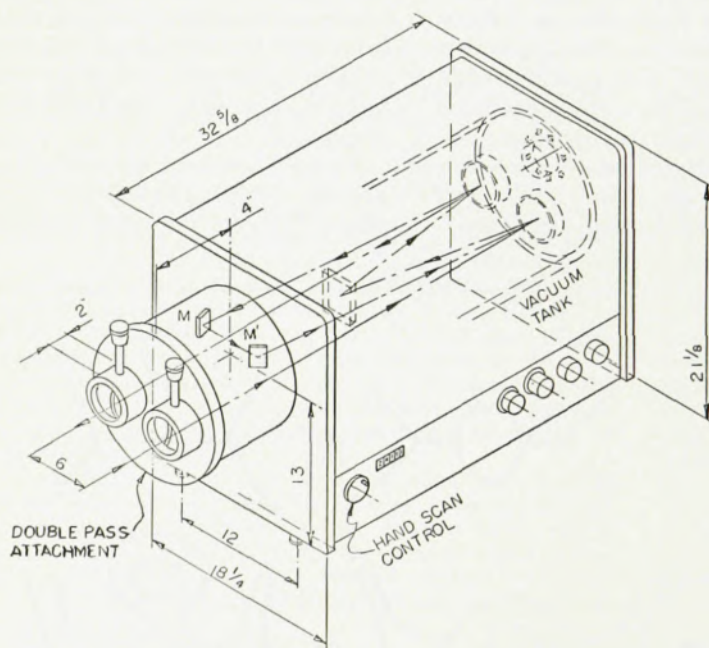
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the poles-only models, these models give a number of embarrassing results—for example, the absence of certain predicted dips at nonsense points of the exchanged trajectories, and the apparent constancy of the Serpukhov π^- and K^- total cross-section data. These are difficulties that are easily eliminated by Regge cuts. Barger advocates use of "effective" Regge poles (effective ρ pole represents ρ pole + $(\rho \times P)$ cut and ρ' represents $(\rho \times P')$ cut, for example) until the nature of these cuts is better understood.

He emphasized the role that continuous-moment sum rules play in constraining the Regge analyses. The $\pi^+\rho$ data up to 26 GeV yield a slope for the Pomeron trajectory of about 0.4. Over the 2–30 GeV range the five poles (P, P', ρ, P'', ρ') accurately represent the elastic and charge-exchange interactions. The Serpukhov data can not, of course, be fit by extrapolating lower-energy pole fits.

Barger found that cuts can reconcile the $K^\pm P$ data with the Pomeronchuk theorem because they push asymptopia to astronomically high energies. He also presented a fit with effective dipoles and poles in which the Pomeronchuk theorem is violated and σ increases as $\log E$. Analyses of backward-scattering data for a number of reactions has been done with baryon-exchange models. Models with exchange-degenerate trajectories (consistent with duality) appear to be good first approximations for the present data. Nondegenerate residues, however, are needed to fit a number of details.

Poles and cuts. Marc H. Ross (University of Michigan) discussed those phenomenological analyses, up to 30 GeV, that use poles and cuts. A number of different groups are doing these calculations, but have major differences in their models. These differences include the form of the Regge pole, the expected size of cuts and the applicability to elastic scattering. Ross confined his talk to the calculations, done at Michigan, in which the Regge poles are not assumed to have nonsense wrong-signature zeroes (in contrast to the usual treatments), and the cut has a free parameter to include inelastic intermediate states.

Destructive interference between poles and cuts (which are then necessarily large) explains the observed

dips. This approach is in contrast to the other treatments (with "weak" cuts) in which the dips are produced by the nonsense wrong-signature zeroes in the residues of the poles. Preliminary qualitative fits (of 4–5 parameters on the average) to a large number of reactions were shown. A crucial problem (of all models) is understanding which reaction will have a dip and which will not. In Ross's model the presence or absence of a dip depends on the relative importance of the helicity flip and nonflip amplitudes. Presumably polarization data will help settle this question.

Finite energy-sum rules and duality have been connected with the most exciting developments in Regge-pole theory in the last two years. In a review Haim Harari (Weizmann Institute of Science, Israel) noted that most recent work has centered on experimental checks of Regge-trajectory exchange degeneracy and the magnitude of exotic exchanges. Useful tests of whether or not two trajectories are exchange degenerate are obtained by comparing line-reversed reactions of the type $A + B \rightarrow C + D$ with $\bar{C} + B \rightarrow \bar{A} + D$ (for example, $K^-p \rightarrow \bar{K}^0n$ and $K^+p \rightarrow K^0n$). If the trajectories dominating these processes are exchange degenerate, the two cross sections should be equal.

Until recently the experimental searches for exotic exchanges have centered on processes dominated by such an exchange. Searches are now proceeding for interference between exotic and nonexotic exchanges that determine the size of the exotic amplitude and not its square. Preliminary results indicate a 10% exotic exchange. Whether this is because of poles or cuts is unclear. Regge cuts and their relation to duality is a major open topic.

A very important product of duality theories and finite energy sum rules has been the Veneziano formula. Claude Lovelace (CERN) discussed theoretical questions and the Veneziano formula as a phenomenological tool. New theoretical ideas have concentrated on a factorization scheme that will permit the inclusion of unitarity without horrendous divergence problems. These divergences occur because of the vast number of resonances appearing in this model. Aside from divergence difficulties, one also needs an interpretation for the large number of states.

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