Hadron Spectroscopy Gains by High Intensity and Electron Cooling

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This ICFA workshop on hadron beam technology is generally oriented toward high energy physics; but some of the discussions can advance low energy hadron spectroscopy -- which in turn can reach into high energy regions through Veneziano model projections [1]. Such projection -- apparently to unlimited energy -- has only recently become feasible, through radial trajectories for light mesons (only u,d,s quarks). These are constructed from observed resonances empirically assigned to identical external parameters (orbital and intrinsic quark spin, isospin and strangeness) but with different masses. These are then fit to the formula:

$$m^2 = An + B$$

where n = 1,2,3,…is the "radial quantum number" and B the trajectory intercept. The Veneziano model requires that the slope A be identical for all such trajectories, while B is unique to the external parameters.

Recent measurements at LEAR have provided sufficient data to evaluate several of the many radial trajectories. The slope A does in fact appear to be universal within errors: Table 1, where the surprising feature is the smallness of the error in A: ~ 0.5 %.

	f	**a**	**K**	**f'**	**Mean**
P0	1.0332±0.0159	1.0720±0.0290	1.0380±0.1189	1.0134±0.0270	1.0361±0.0123
P2	1.0444±0.0079	1.0335±0.0142	1.0503±0.0366	1.0420±0.0229	1.0421±0.0065
F2	1.0429±0.0360	1.0076±0.0434		1.0090±0.1212	1.0275±0.0270
Mean	1.0422+0.0070	1.0383+0.0124	1.0492+0.0352	1.0296+0.0173	1.0420+0.0056

Table 1. Eleven radial slopes are summarized [2]. The row and column averages are averaged in turn to A = 1.0420 ± .0056 GeV^2 in the lower right-hand box. No single table entry differs from that value by more than one standard deviation, indicating a universal slope.

Given this encouragement for projection to indefinitely high energies, it is essential to improve the low energy hadron beams for hadron spectroscopy. Reducing the error on A will extend the range of precise prediction at higher energy.

Remember that 90+ % of hadron spectra have arisen from study with hadron beams, the remainder deriving from photon and electron excitation. As a concrete example, consider the D6 line at Brookhaven National Laboratory: doubly separated pi-, K- and pbar up to ~ 1.9 GeV/c covering much the same range as LEAR. Of the estimated ~ 170 non-strange mesons accessible to pbar-p in this range, only some 40% are known today and only about half of those are of good precision

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[1] G. Veneziano, Nuovo Cim. 57A, 190 (1968).
[2] C. E. Allgower and D. C. Peaslee, Phys. Lett. B 513, 273 (2001).

At this workshop Dr, Weng discussed plans to raise to raise the AGS Intensity to ~ 10^{14} protons per pulse every couple of seconds. The yield of 1-2 GeV/c antiprotons from 24 GeV/c protons is 10^{-8} to 10^{-7}; the pbars emerge from the D6 line with +/-3 % uncertainty in momentum. To be commensurate with the present error in A, that spread should be reduced to ~ 0.3 %. Discussions of electron cooling at this workshop have made clear that this is readily possible with a small storage ring.

Hopefully, when the ICFA cycle next returns to the present topic, calculations and/or tests can be presented: for example, expansion of "translatable templates" (Figure 1.)

The “Template” Idea:

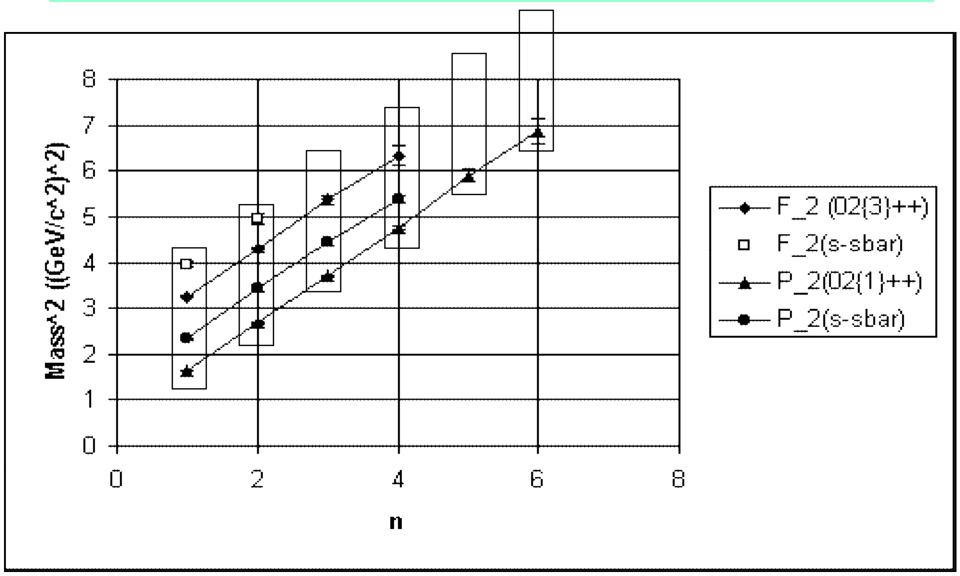

Figure 1. A “translatable template” diagram illustrates the Veneziano radial model. Vertical columns labeled by radial n display identical templates: the m^2 pattern of any number of light q-qbar mesons with different external parameters. To map all such mesons:

Item 1 is of current interest to establish the projective power of the model to arbitrary high energies;

1. Shifting the template by units of n and A yields mass predictions for undiscovered meson resonances.

Item 2, if successful, will distinguish pure Regge trajectories.

2. Only the n=1 template need be extended to all four spin-orbit aspects and indefinitely high Regge orbitals.