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SUMMARY OF MESON '98 WORKSHOP*

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One never quite knows what to say in a summary. If you were at the sessions, you heard the same talks I did. Perhaps the purpose is to summarize the parallel sessions, but like you, I can only attend one of these sessions. In addition, the time is short, so that this cannot be a real summary. What I will present are impressions of the past two days, and these will certainly be colored by my own views. Thus at the outset, let me apologize for any and all omissions and distortions. I will cover primarily the plenary session talks, but will organize this summary along the following lines:

1. vector (V) mesons;
2. pseudoscalar mesons, and
3. other subjects, notably with electrons.

This afternoon's talks are so close in time to this summary that I shall omit them.

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1. Vector mesons

We heard a number of talks on vector mesons. The first of these, by A. Thomas, discussed both CP violation and isospin symmetry. He pointed out that in $B^{\pm}$ meson decays to $\rho^{\pm}\pi^{+}\pi^{-}$ one can make use of $\rho-\omega$ mixing to measure CP violation through an interference of the tree diagram with a penguin which only goes through the ω. In the detection of $\pi^{+}\pi^{-}$ from ρ decay one thus makes use of ρ–ω mixing. This is an interesting proposal which depends on a considerable amount of theory. The branching ratio for the interference is at best $\sim 10^{-6}$; I believe that this is a hard way to

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measure CP or $\rho - \omega$ interference, but it serves as a test of the theoretical description of the decay, particularly the assumption of factorization in the amplitudes.

Next we heard from V. Koch about the interesting question of what happens to vector mesons in a nucleus or nuclear medium. He reminded us that there are a number of scenarios for the ρ:

1. Brown–Rho (B–R) scaling, where $m\rho^*/m\rho \sim 0.78$ if $\rho \sim \rho_N$,
2. many–body calculations involving the pions and their known interactions with nuclei, and
3. $\Delta, \bar{N}$ (holes) or $N^*\bar{N}$ (holes).

The latter two predict enhancements in Γ_ρ but small shifts in mass. The CERES data are ambiguous; they may show an excess of lepton pairs (from vector meson-decays) at $M^* \sim 350$ MeV, but the errors are still too large to reach any meaningful conclusions. The plot of the number of lepton pairs, $N(l^+l^-)$, *vs.* p_T may have a low p_T enhancement, but the data are not conclusive and the extra events could come from secondary scatterings. Koch proposed a disoriented chiral condensate as a possible means of getting the low p_T enhancement and urged that acceptances of l^+l^- pairs be lowered from the present 200 MeV to 60 MeV in order to obtain a more definitive answer.

Friman discussed his and others' meson–nuclear scattering calculations for understanding the ρ in a nuclear medium. He relates any shift in mass directly to the S-wave scattering length and width change to the P-wave scattering amplitude. Parameters are determined by $\pi N \to VN$. They find an increase in the ω-meson in medium mass and a broadening of the ρ-width, but essentially no mass shift for the ρ. It is my view that the last word has not been said. It is not clear to me why B–R scaling should hold for all vector mesons and why the nuclear explanations should not have some validity.

We heard from Y. Bedfer about ϕ and ω meson production at SATURNE. This is a relevant test for OZI inhibition of $s\bar{s}$ production in pp collisions. They compare $\frac{pp\to\phi X}{pp\to\omega X} = R$ as a function of η with $\eta = (\sqrt{s} - \sqrt{s_{\rm thr}})$ Although they find an enhancement over calculation by ~ 8, the ratio R varies from $10^{-3} - 10^{-2}$ as η increases from 0 to 10 GeV. These values are far removed from those found in $\frac{\bar{p}p\to\phi\pi}{\bar{p}p\to\omega\pi}$, *etc.*, where $R \sim 10^{-1}$. Thus, it appears that close to threshold the OZI rule is approximately valid in this production process unlike $p\bar{p}$ annihilation.

From K. Piotrzkowski we heard about diffractive V photo- and electroproduction at much higher energies at HERA. The dependence of the cross section on W and the s-channel helicity are both consistent with a soft pomeron or a Regge-type non-perturbative process. The slope b in $\mathrm{e}^{-b|t|} \sim$

10 GeV^{-2} for all low mass V's (ρ, ω, ϕ). By contrast the J/ψ diffractive production appears to be consistent with pQCD. The exclusive electroproduction of ρ^0 shows a decrease in the slope as Q^2 increases from the canonical value of 10 GeV^{-2} to ~ 4 GeV^{-2}. It thus appears that electroproduction at large Q^2 has an underlying hard Pomeron, but more data are required.

2. Pseudoscalar mesons

The first talk on PS mesons concerned pion absorption in $A > 4$ with LADS. Kotlinski showed the analysis in terms multi(N)- nucleon absorption (*e.g.* $3p$'s, $3p$'s$+n$, ...). The peaks of the partial cross sections increase with N. The fraction of N-particle absorption increases with the A of the target. It would be interesting to be able to isolate the direct multi-particle absorption from rescattering corrections with emission of secondary N's. To disentangle these effects, a good theoretical model is required. Also one might hope that the data with light nuclei of increasing A (*e.g.*, $A = 2, 3, 4, 6, \ldots$) might help, but this is obviously not enough.

Next we heard from A. Gillitzer about the deeply bound π^- state found in the ^{208}Pb (d, ^{3}He) reaction. This is beautiful work based on ideas of Toki *et al.*, and requires excellent resolution and a good understanding of the spectrum of ^{207}Pb. There is no reason that either the target or beam are unique and other reactions should find similar states, but in all cases high resolution and a good knowledge of the spectrum are required. Gillitzer also reported on the effective π mass in the nucleus; it is 160 MeV in agreement with a calculation of Weise.

Pancella discussed recent preliminary data on pion production with polarized beams and targets carried out by the PINTEX collaboration at Indiana University. The data for $pp \to pp\pi^0$ and $d\pi^+$ near threshold should help our understanding of this inhibited production process. W. Garske presented similar data taken at COSY, but at higher energies where the pion P-wave is also important. The σ dependence on energy and its angular distribution are in agreement with expectation. They have also measured η production in $pd \to \eta^3$He. I believe that polarization data would be helpful in separating various production amplitudes and in assuring our understanding of the production process.

In the parallel sessions, Clement discussed single and double π charge exchange (CX). He reminded us of the $A^{-10/3}$ dependence of the σ to analog states vs. the $A^{-4/3}$ for the correlated pair DCX contribution to non-analog states. These A-dependences can be understood readily from π absorption on two separated or correlated nucleons. There were further talks on π and η mesons, but time does not allow me to go into them.

P. Singer discussed K^- and K^+ production at so–called subthreshold energies in heavy ion collisions at GSI. This process gives important information on the behavior of these mesons in the medium. Because of the weak interaction of the K^+ its mass change is small. Due to the weak repulsive K^+ nuclear interaction, its mass increases only slowly with density. By contrast, the K^- mass is expected to decrease rapidly. This decrease enhances K^- production in A–A collisions vs. production in pp collisions. The data are consistent with this decrease; K^- and K^+ production are equal at equivalent $\eta = \sqrt{s} - \sqrt{s_{\rm thr}}$. It also appears that the effective mass $m^*(K^-)$ depends on $\vec{p}_{K^-}$ in the medium and increases as $\vec{p}$ increases. This suggests that the effective K^- nuclear interaction is momentum-dependent.

B. Krusche presented data on π and 2π photoproduction with TAPS at MAMI. Two pion production occurs in a region where the production is complicated by possible contributions of nucleon resonances, rho meson, etc. The $\pi^0\pi^0$ data appear to be particularly sensitive to the resonances and the theory overestimates the cross section. There are clearly interference phenomena between the various mechanisms which affect this σ. The $A(\gamma,\pi^0)A$ cross section is sensitive to the Δ and is consistent with an increase of Γ_Δ of 20–30 MeV, as anticipated from theory. They also observe a small enhancement of the η photoproduction cross section near threshold, which is not yet understood.

3. Other

Ch. Fuget presented the preliminary data from CEBAF on the tensor polarization (t_2)of the deuteron obtained in elastic e–d scattering. This is of particular interest because t_{20} may allow one to distinguish between various models. For instance, at what momentum transfer Q might pQCD and the quark–gluon picture become more important than nucleons and mesons. The data of t_{20} (70°) vs Q^2 can be explained in terms of a non-relativistic impulse approximation plus meson exchange currents plus relativistic corrections up to the highest measured $Q^2 \sim 2$ GeV^2. At best it appears that pQCD may become valid at the highest measured Q^2.

H. Stroeher discussed the polarizabilities of the nucleons. Although the data from real and virtual Compton scattering agree with the sum rule, the individual electric and magnetic polarizabilities of the p and n are still poorly known. Data with polarized real or virtual photons clearly would be helpful and will be forthcoming at MAMI.

You will surely have noted that a considerable part of the conference dealt with the changing properties of hadrons in nuclei or nuclear matter. These changes, first noted in the so-called EMC effects, are both interesting and important. Both the experiemental and theoretical tools are becoming available to allow us to examine these nuclear effects.