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CONCERNING THE LETTER BY P. V. VAVILOV, "THE INTERACTION CROSS SECTION OF PI MESONS AND NUCLEONS AT HIGH ENERGIES"

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IN the articles cited[1] the total cross section for the interaction of pions with nucleons at infinitely large energies are calculated with the aid of a dispersion relation, usually called the inverse relation, which expresses the imaginary part of the forward-scattering amplitude in terms of the real part of this amplitude. The real part of the amplitude, on the other hand, is calculated in the work of Cool et al.,[2] which Vavilov uses, from experimental data on the total cross sections for the interaction of pions with nucleons, and the dispersion relation employed is direct with respect to the above-mentioned inverse relation.

Since experimental data on the total cross sections are available only up to 1770 Mev for positive pions and to 4500 Mev for negative ones, total interaction cross sections, extrapolated for infinite energies at a constant level of approximately 30 millibarns, are used in Ref. 2 to calculate the real part of the amplitude of the elastic forward scattering. No wonder therefore that the cross section obtained in Ref. 1 is $\sigma_\infty = 30$ millibarns. The result of such a calculation is not the prediction of a quantity not yet measured experimentally, but a verification of the compatibility of the employed direct and inverse dispersion relations. Such an agreement should obtain for any extrapolation of the total cross section, and is independent of the accuracy of the experimental quantities.

The contents of the note referred to can also be represented as a calculation of the sections $\sigma_\pm(\omega)$ with the aid of relations of the form

$$\sigma_\pm(\omega) = F_\pm(\omega) + \int_0^\infty \{K_{\pm,+}(\omega,\omega')\,\sigma_+(\omega') + K_{\pm,-}(\omega,\omega')\,\sigma_-(\omega')\}\,d\omega', \tag{1}$$

which are obtained when the real parts of the forward scattering amplitudes $D_\pm(\omega)$ are eliminated from the direct and inverse dispersion relations. But such an elimination, if one considers that

$$\int_{-\infty}^{\infty} dx \,/\, (x-a)(x-b) = \pi^2\delta(a-b), \tag{2}$$

yields

$$F_\pm(\omega) = K_{+,-}(\omega,\omega') = K_{-,+}(\omega,\omega') = 0,$$
$$K_{+,+}(\omega,\omega') = K_{-,-}(\omega,\omega') = \delta(\omega-\omega'),$$

and relation (1) turns into the identity $\sigma_\pm(\omega) = \sigma_\pm(\omega)$, which would be meaningless to verify experimentally.

To refute the widely held opinion that the dispersion relation yields results that are totally insensitive to the behavior of the cross sections at $\sigma \to \infty$, let us consider a simple example. Let us add to cross sections $\sigma_+(\omega)$ and $\sigma_-(\omega)$ a constant cross section σ_0 in the frequency interval $\omega > \omega_0$. Then, as can be readily verified, the real parts of the amplitudes $D_+(\omega)$ and $D_-(\omega)$ are increased by

$$\Delta D_\pm(\omega) = \sigma_0 \frac{\sqrt{\omega^2-\mu^2}}{4\pi^2} \ln \frac{\sqrt{\omega_0^2-\mu^2}+\sqrt{\omega^2-\mu^2}}{\left|\sqrt{\omega_0^2-\mu^2}-\sqrt{\omega^2-\mu^2}\right|}. \tag{3}$$

This quantity is really small when $\omega \ll \omega_0$, but this does not necessarily hold for all frequencies. Inserting $\Delta D_\pm(\omega)$ into the inverse dispersion relation quoted by Vavilov, we find that the cross sections $\sigma_+(\omega)$ and $\sigma_-(\omega)$ are increased by zero when $\omega < \omega_0$, and increased by σ_0 when $\omega > \omega_0$, since at $\omega > \omega_0$

$$\int_0^\infty \frac{d\omega'}{(\omega'^2-\omega^2)\sqrt{\omega'^2-\mu^2}} \times \ln \frac{\left|\sqrt{\omega_0^2-\mu^2}-\sqrt{\omega'^2-\mu^2}\right|}{\sqrt{\omega_0^2-\mu^2}+\sqrt{\omega'^2-\mu^2}} = \frac{\pi^2}{2\omega\sqrt{\omega^2-\mu^2}} \tag{4}$$

and the integral (4) vanishes when $\omega < \omega_0$. This result can be readily checked by integrating in the complex plane of the variable ω', provided we take into account that a singular integral with a parameter, lying on the path of integration, is equal in the limit to half the sum of the integrals with complex parameters, lying on opposite sides of the path of integration. Thus, no matter how high the frequency ω_0, the cross section σ_∞, obtained by successive employment of the direct and inverse dispersion relations, will be determined by that level, to which the experimental cross sections are extrapolated.

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MEASUREMENT OF THE VELOCITY OF SOUND IN LIQUIDS UNDER PRESSURES UP TO 2500 ATMOSPHERES BY AN OPTICAL METHOD

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SEVERAL different methods of measurement have been employed for the measurement of the velocity of sound in a liquid which is under pressure. The most widespread is an optical method which utilizes the diffraction of light on ultrasonic waves which are propagated perpendicular to the beam of light in the liquid. This method, proposed by Debye and Sears,[1] has found wide use in measurements of the velocity of sound in liquids and compressed gases.

Biquard[2,3] measured the velocity of sound in several liquids under pressures up to 600 atmospheres, at temperatures in the range of room temperature. It seems of interest to measure the velocity of sound in liquids at still higher pressures, where one might already expect compression of the very molecules.

The optical scheme of the apparatus which we employed[4] is shown in Fig. 1. A SVDSh mercury lamp served as the source of light S. A slit A_1 was set in the path of the light beam. Condenser K produced a parallel beam of light. A second slit A_2, perpendicular to the first, cut out a narrow pencil of the beam which, after going through the liquid being studied, was focused by the long-focus collecting lens O onto the plate of a microphoto attachment. In order to get narrow diffraction lines, a light filter was used which transmitted the 5770 and 5790 A yellow lines.

The ultrasonic vibrations were excited by an X-cut piezo-quartz plate inserted in the oscillating circuit of a high frequency generator wired in push-pull. This generator used a GU-29 tube. The range of working frequencies was 3 — 4 Mcs. The generator was tuned so that the quartz plate operated at a frequency close to its natural frequency of oscillation. The frequency of the generator was measured by means of a heterodyne wavemeter; with this, the accuracy of the frequency measurements could be regarded as within 400 cycles at working frequencies of 3 — 4 Mcs. The ultrasonic waves passed into the vessel and the liquid being studied through a steel wall, inasmuch as the piezo-quartz plate was placed outside the vessel and was pressed against its ground surface by a light spring. This considerably simplified the construction of the high-pressure ves-

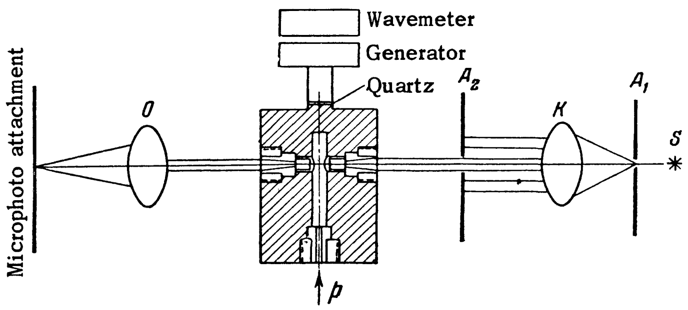

FIG. 1