defined, but βR_w compares well with previously reported values, as can be seen in Table I, again indicating the dominance of the imaginary form factor.

It should be noted that at large angles the complex form-factor predictions have lost most of their structure, while the shape of the real-form prediction is in rough agreement with the data. This suggests that the distorted-wave prescription is suppressing important contributions from the interior—due most probably to the large strength of the imaginary potential needed to fit the elastic scattering.

It is well known that the strong quadrupole state accounts for some 30% of the imaginary well depth W for nucleons, and it is reasonable to expect a comparable or large effect in this case. We are presently investigating the inclusion of the 2^+ state in "coupled equations,"[9] and these results, as well as a more complete discussion of the data and theoretical analysis, will be presented in due course.

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CONTINUUM RESONANCES IN $He^4(p,p')He^{4*}$ †

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Two and possibly three resonances have been seen in the inelastic-proton continuum resulting from 40-MeV proton bombardment of a NTP He^4 gas target. The incident proton energy, E_p, was defined to within ±60 keV by an edge-focused 60° wedge magnet. The gas target was kept in continuous flow to preclude chamber contamination due to (1) out gassing, or (2) residual air left in the vessel during gas transfer. Background spectra with air as the target revealed no proton-continuum structure in the region of excitation, $19 \le E^* \le 24$ MeV, observed in He^4. Throughout the angular range of the experiment, $15° \le \theta_{lab} \le 90°$, inelastic protons were detected by an array of 32 solid-state passing detectors mounted in the focal plane of a 180° double-focusing magnetic spectrometer. Neglecting the logarithmic term in the energy-loss formula, it is easily shown that the pulse height of a passing particle at a given magnetic field and fixed radius of curvature is proportional to its mass squared. Thus d, T, He^3, and He^4 particles were discriminated against after the expected He^4 inelastic-proton pulse height was determined from an $H(p,p)H$ scattering at an appropriate angle. Hydrogen elastic scattering was also used to energy-calibrate the spectrometer magnetic field. Thus, with a knowledge of incident beam energy, target purity, and detected particle type and energy, an absolute determination of the resonance Q values could be obtained. The lowest excitation, and relatively narrow resonance (I) occur at 0.64 ±0.14 MeV above the continuum onset due to the reaction ($He^4 + p \rightarrow 2p + T$). The second and broader resonance occurs at 2.18 ± 0.14 MeV above the $p+T$ breakup point. From Figs. 1 and 2, which show $\partial^2\sigma/\partial\omega\,\partial p$ versus spectrometer field (B_0) at $\theta = 25°$ and 52°, respectively, it is seen that both peaks are superimposed upon a background consisting of phase-space continuum and an additional experimental "flat" continuum which is observed at B_0 values above

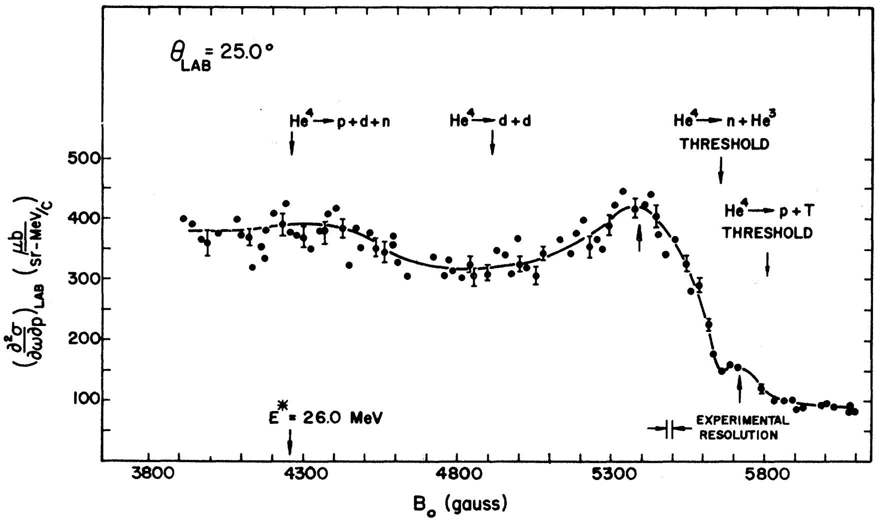

FIG. 1. Momentum spectrum of inelastic protons at $\theta_{lab} = 25°$.

$p + T$ onset ($Q = -19.82$ MeV). The flat background is thought to be due to elastic protons which have been energy-degraded in the solid-angle-defining baffles placed inside the spectrometer and by neutrons produced in the energy-defining beam collimators. To determine the actual full width at half-maximum (Γ's) and cross sections for each of the two peaks, a subtraction of at least one of these two backgrounds was made.

In the case of peak *I* at $E^* = 20.46$ MeV, both the flat continuum and phase-space backgrounds were equated to the dashed curve shown under this resonance in Fig. 2. The discrete peak resulting from a subtraction of the dashed curve from the data had a $\Gamma_\pm$ of 450 ± 70 keV. Integration of the discrete peak over the inelastic proton's momentum yielded a $(d\sigma/d\omega)_I$ which, if transferred to c.m. coordinates, appears to decrease at small angles with a maximum value of 140 ± 10 μb/sr near $\theta_{c.m.} = 65°$. Peak II at $E^* = 22.00 \pm 0.14$ MeV appears larger than

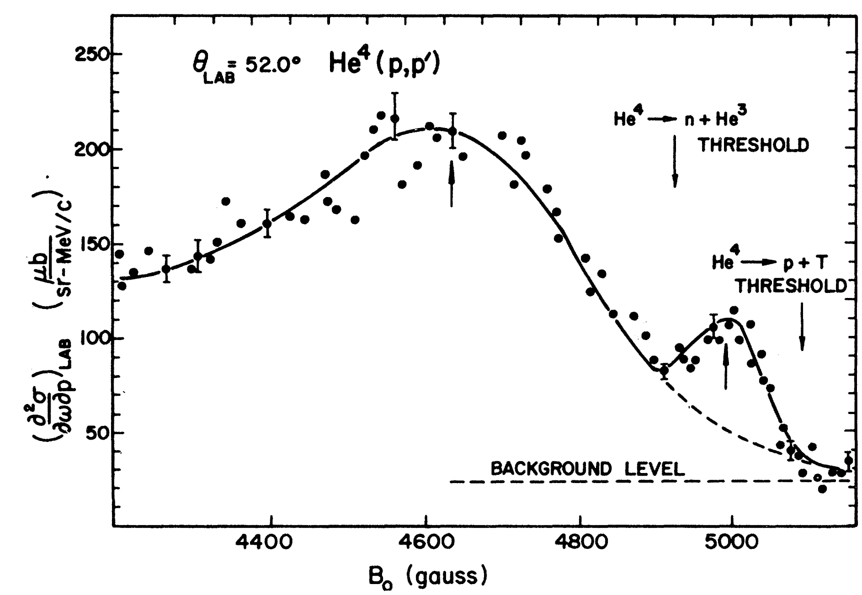

FIG. 2. Momentum spectrum of inelastic protons at $\theta_{lab} = 52°$.

Table I. Summary of resonance parameters. All errors are rms.

Resonance	E^* (excitation energy) (MeV)	Γ (full width at half-maximum) 1 (MeV)
I	20.46 ± 0.14	0.45 ± 0.07
II	22.00 ± 0.14	3.5 ± 0.2

peak I at all angles and monitonically decreases with increasing c.m. angle. Because of the present uncertainty of the background subtraction for peak II, no definite $(d\sigma/d\omega)_{\text{II}}$ values can be given for the second resonance. Subtracting the extrapolated flat continuum only, Γ_{II} was found to be 3.5 ± 0.2 MeV. These tentative results are summarized in Table I.

At $\theta_{\text{lab}} = 25°$, the empirical resolution was calculated to be 170 keV (full width at half-maximum), and is shown in Fig. 1. This minimum width was predominately due to the incident proton's energy uncertainty and a kinematic energy variation of ±60 keV in the scattered beam. The standard deviation of the Landau energy spread in the target and foils was, at this angle, about ±35 keV. These values are typical of those at other lab angles and the calculated resolution is in fair agreement with the empirical errors in E^* and Γ noted in Table I.

Peak I appears to be associated with the $J^\pi = 0^+$ state calculated by Werntz[1] and Meyerhof[2] and, in a recent article by Szydlik and Werntz,[3] has been described as an isotopic-spin $T = 0$ state. It has not been previously seen in (p, p') scattering. Peak II is an enigma of $He^4(p, p')$ experiments, which, when seen,[4,5] has been explained by quasielastic scattering[6,7] ($E_p \gg 20$ MeV). In our case, E_p is about 40 MeV and peak II is still observable. This may strengthen the argument for it being a virtual state with the possibility of correlating it with other resonances seen near $E^* = 22$ MeV[8,9] or with the higher excitation peak seen by Parker et al.[10] in the $He^3 + d$ reaction continuum. No unequivocal values of J^π or T are known for resonance II.

As Fig. 1 shows, a third peak has possibly begun to appear at $26 \leq E^* \leq 28$ MeV. Unfortunately, we cannot follow this resonance due to kinematic limitations, due to the relatively low E_p value of the experiment. This structure is in the region of E^* values corresponding to a $He^4(\gamma, p)T$ experimental resonance[11,12] seen previously. It may, therefore, be a $J^\pi = 1^-$ state with $T = 1$.[13]

No bound ($E^* \leq 19.82$ MeV) excited states have been seen so far in this experiment. Spectra taken at $\theta_{\text{lab}} = 52°$ down to $E^* = 15.8$ MeV have revealed no structure on the flat continuum mentioned previously.

A more complete account of this work will be submitted shortly.

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