duced by Marchand on the basis of susceptibility measurement[3] for pyrolytic carbons is about $\frac{1}{10}$ of that for single-crystal graphite. The density of states in graphite is expressed as

$$N(E)=\frac{8}{3\pi^2\gamma_0^2a^2c_0}\{\pi\,|E|+2\gamma_1\}.$$

If one neglects the first term in this expression, Marchand's result leads to an effective mass of $\frac{1}{10}$ of the single-crystal value.

We also have some evidence of large tunneling probabilities in a silicon pyrolytic carbon junction,[2,4] which again supports the assumption of the extremely small mass of the carriers.

All these experimental findings seem to coincide in leading to the result that the effective mass of the carriers in some pyrolytic carbons is much smaller than it is in single crystals. The only hindrance to this conclusion is the problem of density of states, since it is known that the carrier concentrations in pyrolytic carbons and in single crystals of graphite do not differ much. This difficulty, however, seems to be overcome when one accepts McClure's treatment[5] for poorly ordered carbons. According to his views, the electronic state in turbostratic carbons should be represented by an assembly of many bands with small densities of states. Since these bands are supposed to converge into four bands as the graphitization proceeds, one should postulate a density of states $1/n$ times that of a single crystal if there are $4n$ such bands.

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ASYMMETRY OF (d,p) CROSS SECTION FOR A POLARIZED He^3 TARGET*

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This Letter discusses the expected left-right asymmetry for the $He^3(d,p)He^4$ (g.s.) reaction when a polarized He^3 target is used. In particular, various types of proton–target-nucleus and proton–final-nucleus interactions have been investigated under the direct-reaction assumption. The relationship between the proton-spin polarization for an unpolarized target, $P(\theta)$, and the left-right asymmetry[1] for a polarized target, $A_{LR}(\theta)$, has then been calculated. The asymmetry $A_{LR}(\theta)$ is defined by

$$A_{LR}(\theta)=q^{-1}[\sigma_L(\theta)-\sigma_R(\theta)]/[\sigma_L(\theta)+\sigma_R(\theta)], \quad (1)$$

where q is the polarization of the target nucleus and $\sigma_L(\theta)$ and $\sigma_R(\theta)$ are the left-side and right-side differential cross sections. Equation (1) is calculated with transition amplitudes[2]

$$A_{LR}(\theta)=\frac{-2\sum_{M_f,\nu_d,\nu_f}\mathrm{Im}\{\langle M_f,\nu_f|T|\nu_d,M_i=\tfrac{1}{2}\rangle^*\langle M_f,\nu_f|T|\nu_d,M_i=-\tfrac{1}{2}\rangle\}}{\sum_{M_f,\nu_d,\nu_f,M_i}|\langle M_f,\nu_f|T|\nu_d,M_i\rangle|^2}, \quad (2)$$

where M_i, M_f, ν_d, and ν_f are the z components of the spins of the target nucleus, the final nucleus, the incident deuteron, and the emitted proton, respectively. The z axis is chosen along the beam direction. The polarization $P(\theta)$ is given by[2]

$$P(\theta)=\frac{2\sum_{M_f,M_i,\nu_d}\mathrm{Im}\{\langle M_f,\nu_f=\tfrac{1}{2}|T|M_i,\nu_d\rangle^*\langle M_f,\nu_f=-\tfrac{1}{2}|T|M_i,\nu_d\rangle\}}{\sum_{M_f,M_i,\nu_d,\nu_f}|\langle M_f,\nu_f|T|M_i,\nu_d\rangle|^2}. \quad (3)$$

The forms of the proton-target interaction V_{pT} and the proton–final-nucleus interaction U_{pF} were assumed as follows:

$$V_{pT}=V_c(r)+V_{sp}(r)\vec{l}_p\cdot\vec{\sigma}_p, \qquad (4a)$$

and

$$V_{pT}=V_c(r)+A\frac{(\vec{\sigma}_p\cdot\vec{r})(\vec{\sigma}_T\cdot\vec{r})}{r^2}+B(\vec{\sigma}_p\cdot\vec{\sigma}_T), \qquad (4b)$$

for the spin-orbit-force assumption and for the tensor-force assumption, respectively; and

$$U_{pF}=U_c(r), \qquad (4c)$$

and

$$U_{pF}=U_c(r)+U_{sp}(r)\vec{l}_p\cdot\vec{\sigma}_p, \qquad (4d)$$

for the central force assumption and for the spin-orbit force assumption, respectively. Since the proton coordinate $\vec{r}$ is defined as the position vector from the center of mass of the neutron-target system, (4a) and (4b) are reasonable assumptions only for the infinite-mass target. A and B are arbitrary constants, and the other notations are defined in the usual way. The antisymmetrization between the proton of the deuteron and protons of the target nucleus was taken into account and, in several cases, the D-state amplitude of the deuteron internal motion was considered. The bound interactions of the neutron and the deuteron are eliminated by their Schrödinger equations. With these assumptions and using the prior form for the transition amplitude, relationships between $A_{LR}(\theta)$ and $P(\theta)$ have been obtained without any numerical calculations. The results are shown in Table I, for various combinations of the assumptions.

It should be noted that the knock-out amplitude has been neglected, because it has been shown to be small in the case of S-wave neutron capture.[3] Also, detailed calculations of the recoil effects for case I changes the listed result, but the effect seems to be too small to fit the experiments.[1]

An examination of Table I shows that the following conclusions can be drawn: (1) The conventional theory (case I) is incapable of fitting the experimental data and thus must be inadequate to describe the reaction. (2) Cases II, III, and IV approximately describe the data, and thus it may be concluded that a tensor p-He^3 interaction and/or a D-state deuteron admixture must be included to describe the process. In case IV, the linear terms in the D-state amplitude vanish identically and only the quadratic term contributes; for this reason it is doubtful that case IV can account for the experimental results. Thus it appears that a tensor interaction of the proton and He^3 is required to describe the experiments. This requires that the spins of both the proton and the He^3 are flipped in the reaction.[3] Theories of the type of case I have been successful in describing the cross section, $\sigma(\theta)$, and $P(\theta)$ for other (d,p) reactions. Since $A_{LR}(\theta)$ has not been measured before, it is possible that these theories will be found inadequate when $A(\theta)$ is measured.

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Table I. The theoretical relationships of $A_{LR}(\theta)$ and $P(\theta)$ are shown for various models. Different forces of the p-He^4 and p-He^3 interactions were used (see text), and one of the two possible exchange effects was included. The deuteron ground-state wave function was chosen as either a pure S state or a mixed S and D state.

	Forces		Exchange effects			
Case	p-He^4 force	p-He^3 force	Heavy-particle stripping	Knock-out	Deuteron wave function	Results
I	Spin-orbit	Spin-orbit	Yes	No	S	$A_{LR}(\theta)=-\frac{1}{3}P(\theta)$
II	Central	Tensor	Yes	No	$S+D$	$A_{LR}(\theta)=-P(\theta)$
III	Central	Tensor	Yes	No	S	$A_{LR}(\theta)=-P(\theta)$
IV	Central	Central	Yes	No	$S+D$	$A_{LR}(\theta)=-P(\theta)$