$(eQ\partial^2 V/\partial z'^2/h)$ of 2500 Mc/sec and thus the magnitude of Q for the excited, spin 2, of even-even Pd^{106} is probably at least as large as 0.2×10^{-24} cm^2.

Finally, it might be remarked that for the factors GkI_B very near unity the attenuation factors for the solid lattice and for the liquid give the same results if τ_N^2 in the formulas for the solid are replaced by $\tau_N\tau_c$. On the other hand, the "relaxation" process involved in the liquid can truly be regarded as a "loss of memory." In contrast, the characteristic frequencies produced by static interactions in solids or by applied fields could be observed by the use of delayed coincidence techniques. Thus the term "loss of memory" in those cases is inappropriate.

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The Use of the Tamm-Dancoff Method in Field Theory

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MANY authors[1] have discussed the application of the Tamm-Dancoff method[2] to problems of field theory. In this method the wave function of a system is represented by the amplitude $a(N)$ for finding a prescribed set N of occupation numbers. N is a set of integers giving the number of particles present in each of the normal modes of the noninteracting fields. Let E_N be the total energy of the free particles specified by N. The Schrödinger equation for a state of the interacting fields with energy E becomes

$$(E-E_N)a(N)=\Sigma_M H'(MN)a(M), \qquad (1)$$

where $H'(MN)$ is the matrix element of the interaction operator H' between the states specified by N and M. The Tamm-Dancoff method consists in breaking off the infinite set of Eq. (1) by omitting all terms involving amplitudes $a(M)$ with more than a fixed number of particles. The finite set of equations so obtained can then be solved by standard methods.

Unfortunately, the method runs into a serious difficulty connected with the vacuum self-energy. When Eq. (1) is iterated once, we obtain

$$(E-E_N)a(N)=\left\{\Sigma_M\frac{H'(MN)H'(NM)}{E-E_M}\right\}a(N)+\text{other terms.} \qquad (2)$$

The sum on the right of (2) is very badly divergent, since H' has matrix elements for creating 3 particles with only one relation between the 3 momenta. This divergence cannot be eliminated by renormalization. It shows a real inadequacy in the Tamm-Dancoff method. Physically, every state of the interacting fields contains very many particles which are continually created and annihilated in the vacuum. Restricting the total wave function to a fixed number of particles imposes an artificial correlation between the vacuum fluctuations at points far distant in space. This artificial correlation makes itself felt in Eq. (2) as a spurious effect of the vacuum fluctuations upon the behavior of real particles.

A simple modification of the Tamm-Dancoff method will avoid this difficulty entirely. Let Ψ be the actual state of the system with energy E, and let Ψ_0 be the vacuum state of the interacting fields with energy E_0. Both E and E_0 are infinite, but the observable difference $\epsilon=E-E_0$ is finite. We write $A(N)$ for the product of free particle annihilation operators which annihilates the particles specified by N, and $C(N)$ for the product of the corresponding creation operators. Instead of the Tamm-Dancoff amplitude $a(N)$, we define

$$a(N', N)=(\Psi_0{}^*C(N')A(N)\Psi). \qquad (3)$$

This describes the amplitude for finding in the actual state Ψ the set N of free particles *minus* the set N'. The minus particles are, loosely speaking, those which are absent in Ψ but present in the physical vacuum state Ψ_0.

The Schrödinger equations for Ψ and Ψ_0 now give

$$(\epsilon-E_N+E_{N'})a(N', N)=(\Psi_0{}^*[C(N')A(N), H']\Psi). \qquad (4)$$

The commutator on the right of Eq. (4) can be expanded into a sum of products of creation and annihilation operators with the creation operators standing on the left[3] as in Eq. (3). Then (4) becomes a set of homogeneous linear equations for the amplitudes $a(N', N)$. These equations can be handled by the standard Tamm-Dancoff technique.

Equations (4) differ from (1) in three respects. (a) The physically observable energy ϵ appears instead of the meaningless quantity E. (b) The commutator on the right of Eq. (4) does not have matrix elements involving 3 particles with 2 arbitrary momenta. Instead one of the particles created or annihilated by H' has to belong to the discrete set specified by N or N', and hence only one degree of freedom is left for the momenta of the 2 remaining particles. This means that divergences of the unpleasant vacuum self-energy type can bo longer appear in the theory. (c) The appearance of "minus" particles in the amplitude $a(N', N)$ restores the symmetry between emission and absorption which is lacking in the Tamm-Dancoff method, and so brings the Tamm-Dancoff method into closer correspondence with formally covariant four-dimensional methods.

[1] This letter was stimulated by an unpublished paper by Marcello Cini, to whom the author is indebted for sending him a preprint.

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The Sign of the Phase Shifts in Meson-Nucleon Scattering

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FERMI and collaborators[1] have made extensive experiments on the scattering of mesons by nucleons and have analyzed their results in terms of phase shifts. As is well known, the sign of *all* phase shifts can be simultaneously reversed without changing the differential cross section. The relative signs are of course determined uniquely; in particular, the phase shifts of the two most important waves, S and $P_{3/2}$ for $I=3/2$, have opposite signs.

Fermi *et al.* have chosen the S wave phase-shift positive which conventionally denotes an attractive interaction. The $P_{3/2}$ shift is then automatically negative, i.e., repulsive.

On the other hand all theoretical papers on this subject make the opposite choice of sign. Indications are that the $P_{3/2}$ state has either an actual resonance or very nearly so which, of course, is only possible for an attractive interaction. The S state interaction, on the other hand, is mainly the strong repulsive "core" which has been discussed especially by Drell and Henley.[2]

The purpose of this note is to point out that there is actually some *experimental* evidence in favor of the choice of the theorists. Such evidence can, of course, only come from the interference of the nuclear scattering of mesons with some other scattering of known sign, and this means with Coulomb scattering. The only conclusive experiment of this type would be the observation of the interference with Coulomb scattering in meson-proton scattering, and Van Hove[3] has pointed out that such interference would be observable at quite reasonable angles (about 20°). However, until now no such experiments have been carried out.

The interference with Coulomb scattering has been observed, however, in the scattering of mesons by carbon nuclei. Byfield, Kessler, and Lederman[4] have shown that at 60-Mev meson energy the interference is constructive for negative, destructive for positive mesons, thus indicating an attractive nuclear interaction with the meson.