The theoretical description of the possible interactions of tachyons has proven to be extremely difficult, and dybbuks undoubtedly will prove at least as difficult. A possible description is outlined as follows. Imaginary energies have been used in atomic and nuclear physics to describe the lifetime of states. If exp iEt is the time-dependent part of a wave function ($\hbar=1$), and E is equal to $\bar{E}_r+\mathrm{i}\bar{E}_i$, then the lifetime of the state is equal to $(\bar{E}_i)^{-1}$. Making this description covariant requires i$\bar{E}_i$ to be enlarged into a four vector. Such a four-vector is the four-vector of a dybbuk. The fundamental interaction of the emission or absorption of a secondary particle (for example, graviton) is assumed to have a characteristic lifetime, τ, induced by a dybbuk of energy i$\bar{E}$, with $\bar{E}=1/\tau$. The three-particle vertex is thus extended into a five particle vertex with two of the particles being dybbuks.

The gravitational constant or the weak coupling constant, for example, is then determined by two five-particle vertices, with the intermediary particle being a graviton or a W-meson, respectively. The strength of the vertex is inversely proportional to the characteristic lifetime. The vertex is also proportional to the dybbuk density which is related to the average density of vertices, $\bar{\rho}_g$. Combining $\bar{\rho}_g$ covariantly with the characteristic lifetime, τ_g, we obtain

$$g = (\tau_g\bar{\rho}_g)^{-2}g_0 \tag{2}$$

where g is the weak coupling constant or the gravitational constant. For the weak coupling constant, $\bar{\rho}_g$ is the average density of leptons plus antileptons, while for the gravitational constant, $\bar{\rho}_g$ is the average mass density. The average is taken over a dybbuk interaction distance, λ_g, which is in units of cm^{-2} and g cm^{-2} for the weak coupling and gravitational constants, respectively.

As an application of the above ideas, I use equation (2) to evaluate the gravitational interaction of a very dense star. The average gravitational constant, G, of a star of mass M and radius R from equation (2) is

$$G \simeq G_0 \qquad \lambda_G \gg \frac{M}{R^2} \tag{3}$$

$$G = (\lambda_G{}^2G_0)\frac{R^4}{M^2} \qquad \lambda_G \ll \frac{M}{R^2} \tag{4}$$

The average gravitational force is equal to the gravitational field times the star density, or using equations (3) and (4) we obtain

$$F_G \propto \frac{M^2}{R^5} \qquad \lambda_G \gg \frac{M}{R^2} \tag{5}$$

$$F_G \propto \frac{M^0}{R} \qquad \lambda_G \ll \frac{M}{R^2} \tag{6}$$

In the case of complete relativistic degeneracy, the pressure due to the degeneracy is proportional to the fourth power of the Fermi momentum, which in turn is proportional to the one-third power of the particle density. The corresponding average repulsive force due to the degeneracy, $\bar{F}_d$, has then the functional dependence

$$\bar{F}_d \propto \frac{M^{4/3}}{R^5} \tag{7}$$

For $\lambda_G \gg M/R^2$, we have from equations (5) and (7) that $\bar{F}_G$ and $\bar{F}_d$ depend on the same power of the radius but on different powers of the mass. This is the reason for the belief that an upper limit exists to the mass of a cold white dwarf or neutron star. A mass larger than this critical limit will induce collapse. We observe, however, from equations (5) and (6) that an R_c sufficiently small always exists, such that $\bar{F}_d > \bar{F}_G$, and no further collapse can occur. In particular, for a collapsing neutron star, if $\lambda_G R_c{}^3/M$ is larger than the Schwartzschild radius, a black hole[10] will not form. If λ_G is comparable with M/R^2 for a neutron star, then from equations (2) and (4) the gravitational radiation from a pulsar is very much less than presently estimated. In fact, there is some evidence that present theories of pulsars may be incorrect[11].

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1 Bilaniuk, O. M. P., Deshpande, V. K., and Sudarshan, E. C. G., *Amer. J. Phys.*, **30**, 718 (1962).
2 Feinberg, G., *Phys. Rev.*, **159**, 1089 (1967).
3 Bilaniuk, O. M. P., and Sudarshan, E. C. G., *Phys. Today*, **22**, 43 (1969).
4 Rolnick, W. B., *Phys. Rev.*, **183**, 1105 (1969).
5 Fox, R., Kuper, C. G., and Lipson, S. G., *Nature*, **223**, 597 (1969).
6 Pirani, F. A. E., *Phys. Rev.*, **D1**, 3224 (1970).
7 Fox, R., Kuper, C. G., and Lipson, S. G., *Proc. Roy. Soc.*, A, **316**, 515 (1970).
8 Benford, G. A., Book, D. L., and Newcomb, W. A., *Phys. Rev.*, **D2**, 263 (1970).
9 Bers, A., Fox, R., Kuper, C. G., and Lipson, S. G., in *Festschrift to Nathan Rosen*, 41 (Gordon and Breach, 1971).
10 Ruffini, R., and Wheeler, J., *Phys. Today*, **24**, 30 (1971).
11 Kristian, J., *Astrophys. J.*, **162**, L174 (1970).

Deferred Luminescence at 4.2 K in an Organic Glass

WE irradiated outgassed methylcyclohexane glass containing biphenyl (concentration 10^{-4} to 10^{-2} mol. dm^3) with γ-rays (dose rate 60 krad h^{-1}, dose 30 krad) in liquid helium and started recording the luminescence emitted 4 min after the end of irradiation. An isothermal decay was observed at 4.2 K for more than 3 h. On subsequent warming the light output increased and the two well known thermoluminescence peaks were observed at 90 and 95 K. In all experiments the integrated light emission during the first 25 min of the decay at 4.2 K amounted to 3 ± 1% of the total deferred luminescence. Blank experiments showed that the luminescence observed at 4.2 K was not due to residual nitrogen. As kT at 4.2 K is only 3.6×10^{-4} eV, thermal detrapping of electrons seems to be excluded at this temperature. Hence it seems that deferred luminescence observed at 4.2 K must be ascribed to tunnelling of electrons trapped very near the cations, probably at a distance less than 15 Å. Measurements of decay kinetics and of the influence of the matrix are in progress.

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