Tachyon Cloud of a Particle

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(Received 15 December 1969)

The similarities and differences of a tachyon cloud surrounding a slower-than-light particle compared to that of a meson cloud surrounding a nucleon are given, and a possible elimination of the infrared-divergence catastrophe in terms of renormalization due to the tachyon cloud is pointed out.

THE calculation performed by Boulware in the preceding Comment[1] displays the structure of the tachyon cloud accompanying a slower-than-light particle coupled to it, which has both similarities and differences when compared with the meson cloud surrounding a nucleon.

If a scalar meson of mass m is coupled to a nuclear source density $\rho(\mathbf{r})$, the (static) meson cloud entailed is

$$\phi(\mathbf{r})=\frac{g}{4\pi}\int\rho(\mathbf{r}')\frac{e^{-m|\mathbf{r}-\mathbf{r}'|}}{|\mathbf{r}-\mathbf{r}'|}d^3r'. \tag{1}$$

This is the particular integral of the (time-independent) equation

$$(\nabla^2-m^2)\phi(\mathbf{r})=-g\rho(\mathbf{r}) \tag{2}$$

satisfied by the meson field. For the special case of $m=0$ we get, as usual, the electrostatic potential.

Let us now consider the tachyon field coupled to a source density $\sigma(\mathbf{r})$. The (time-independent) Poisson equation is

$$(\nabla^2+\mu^2)\chi(\mathbf{r})=-g\sigma(\mathbf{r}). \tag{3}$$

The particular integral is

$$\chi(\mathbf{r})=\frac{g}{4\pi}\int\sigma(r')\frac{e^{i\mu|\mathbf{r}-\mathbf{r}'|}}{|\mathbf{r}-\mathbf{r}'|}d^3r'. \tag{4}$$

We note that the amplitude of this tachyon cloud is no longer real; the complex conjugate is also a particular integral

$$\chi'(\mathbf{r})=\frac{g}{4\pi}\int\sigma(r')\frac{e^{-i\mu|\mathbf{r}-\mathbf{r}'|}}{|\mathbf{r}-\mathbf{r}'|}d^3r'. \tag{5}$$

We have the freedom to choose either (4) or (5) for the virtual tachyon cloud; we could also take the real amplitude

$$\chi(r)=\frac{g}{4\pi}\int\sigma(\mathbf{r}')\frac{\cos(\mu|\mathbf{r}-\mathbf{r}'|)}{|\mathbf{r}-\mathbf{r}'|}d^3r'. \tag{6}$$

Each of these choices reflects itself in the structure of the propagator of the tachyon source. The specific choice made by us for tachyon field theory[2] leads to a branch point at $m+i\mu$. The alternate choices of the virtual tachyon cloud correspond to the possibility of a new kind of "renormalization," but it must always be remembered that it is a redefinition of the physical particle (with its attendant tachyon cloud). This kind of redefinition of particle states is, of course, essential even for the case of photon clouds to avoid the infrared catastrophe.

[1] D. S. Boulware, preceding Comment, Phys. Rev. D 1, 2426 (1970).

[2] J. Dhar and E. C. G. Sudarshan, Phys. Rev. 174, 1808 (1968).