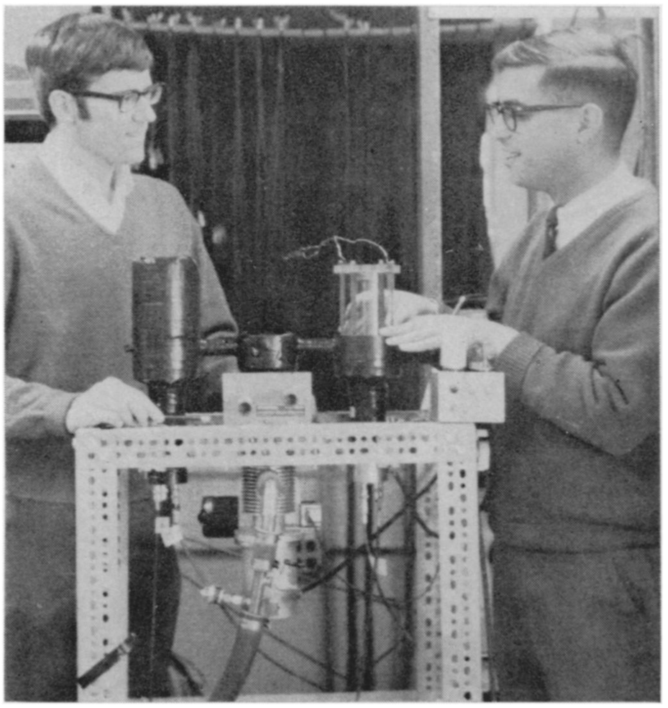
A certain young lady named Bright

Could travel much faster than light.

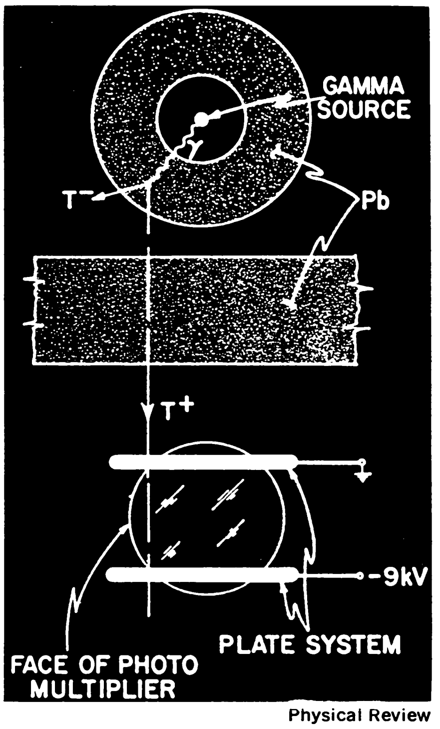
She departed one day

In a relative way

And returned on the previous night.



(left) Michael Davis, Dr. M. N. Kreisler seek tachyons.



Physical Review

Alväger-Kreisler experiment.

TACHYONS

Particles through the looking glass

by Dietrick E. Thomsen

An experiment done in Cleveland in 1887 by Albert A. Michelson and Edward W. Morley showed that no material object can move faster than the speed of light. The result was conclusive enough to set some of the best physical and mathematical minds of that generation, including H. A. Lorentz, Albert Einstein and Herman Minkowski, to work on a thorough revision of the theory of space and time.

The picture they evolved, called special relativity, looks rather bizarre to common sense intuition, but it had to be accepted along with the evidence that the speed of light, about 300,000 kilometers a second, is a kind of cosmic speed limit.

The formula of special relativity shows that the energy of a particle will become infinite as its speed approaches that of light. From this Einstein concluded: ". . . velocities greater than that of light . . . have no possibility of existence."

But Dr. Gerald Feinberg of Columbia University (SN: 10/9/67, p. 242), objects: ". . . the standard arguments are not compelling in the context of relativistic quantum mechanics with its characteristic discontinuous creation of particles. . . . particles might be created . . . without any necessity of accelerating ordinary particles through the 'light barrier'."

Other dissenters from the standard view include Drs. E. C. G. Sudarshan of Syracuse University, O. M. P. Bilaniuk of Swarthmore College, V. K. Deshpande, who worked with Drs. Sudarshan and Bilaniuk at Rochester University, Sho Tanaka of Kyoto University, M. E. Arons of City College of New York and J. Dhar of the University of Delhi.

In their view the speed of light becomes a two-sided limit instead of a one-sided one. Particles that go faster than light can exist, they say, so long as their velocity never falls below that of light, and the limiting speed divides ordinary particles which can never exceed it from a class of particles which can never go below it. Dr. Feinberg named the faster-than-light particles tachyons from the Greek word tachys, meaning swift.

Theories of the nature and behavior of tachyons are being worked out, especially by Dr. Sudarshan and various colleagues and by Dr. Feinberg. Though the two sides differ in parts of their theories, they concur in presenting tachyons as particles with some strange, through-the-looking-glass qualities.

But the properties of tachyons are not wild enough to be entirely daunting to experimenters. At least two experimenters are currently looking for them.

In order for a tachyon's momentum and energy, its experimentally measurable qualities, to be real, it has to have a mathematically imaginary rest mass. This does not mean that the particle itself is physically imaginary, and, say Drs. Dhar and Sudarshan: ". . . this leads to no conceptual difficulties since these particles cannot be brought to rest." Thus it doesn't matter what their mathematical rest mass is; it will never be physically significant.

The serious problem, in the view of these theoreticians, is that if one considers a particular tachyon action and views it from a variety of frames of reference, there will be some frames in which a tachyon appears to have negative energy.

Another way of expressing the same difficulty is that, like the lady in the limerick, a tachyon may sometimes arrive on the previous night. As Drs. Torsten Alväger of Indiana State University and Michael N. Kreisler of Princeton put it: "Let such a particle be emitted from a source A and absorbed at a detector B. . . . the observer in [a particular reference frame] should see the particle before it was emitted."

Critics have concentrated fire on this because it seems to violate a cherished physical principle, that of causality. The causality principle insists that a cause must come before its effect. According to special relativity, changing the frame of reference may lengthen or shorten the time between two events, but if anything real is going on, changing the reference frame should not reverse the order of events.

The solution to this problem, say tachyon proponents, is to reverse, not the order of events, but one's interpretation of them, as one goes from reference frame to reference frame. "Crucial to the resolution of the difficulty is the reinterpretation of 'negative-energy particles traveling backward in time' to be positive-energy particles traveling forward in time," say Drs. Dhar and Sudarshan. Or, as Drs. Alväger and Kreisler continue their example: "the observer . . . could thus interpret the particle path, not as starting at A and ending at B, but the reverse. That is, he would see an oppositely charged particle going from B to A."

Ordinary particles gain energy as their speed increases; tachyons lose energy as their speed increases. A tachyon's greatest energy will occur near the speed of light, while at infinite speed it will have no energy.

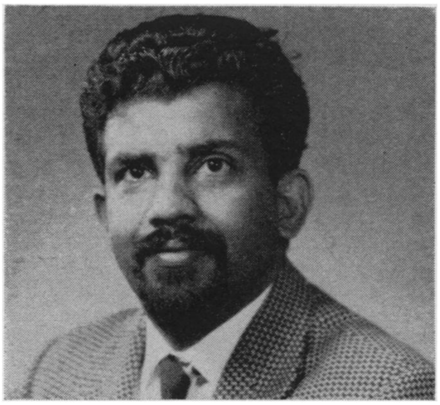
Tachyons should be created in pairs, and, say Drs. Alväger and Kreisler, they can be made with zero energy input. This means, in principle, that tachyons could pop up spontaneously just about anywhere. However, tachyons are theoretically bound to behave according to a set of statistical laws developed by Enrico Fermi and P. A. M. Dirac. These Fermi-Dirac statisitcs allow only a limited number of particles in any energy state, and Drs. Alväger and Kreisler suggest that the reason such spontaneous tachyons do not appear is that the energy states into which they could go are already filled by other particles.

Electrically charged tachyons would also emit Cerenkov radiation in vacuum. Cerenkov radiation is light emitted by ordinary particles when they are traveling through a medium in which the speed of light is less than their own speed. This can happen because the speed of light in thick media like water or oil is a good deal less than the speed of light in vacuum.

Tachyons, however, go faster than the speed of light even in vacuum, and they would therefore emit Cerenkov radiation even in vacuum.

This property is the basis of an experiment that Drs. Kreisler and Alväger set up at Princeton in their search for charged tachyons. They took a source of gamma rays and surrounded it with a lead cylinder. The gamma rays interacting with the lead, they hoped, would produce tachyons. The tachyons would then come through some auxiliary shielding and into the space between two electrified plates. The plates were to set up an electric field that would supply enough energy to the tachyons for them to emit observable Cerenkov radiation. A photomultiplier tube would record the radiation.

The experiment didn't find any tachyons but it set an upper limit on the probability (cross section) for tachyon production in lead of three microbarns at an energy of 800,000 electron volts. This would hold for tachyons whose electric charge might be anything from 0.1 to 2 electron charges. (One microbarn is 10^{-30} square centimeters or about a millionth of the cross section of an atomic nucleus.)



Sudarshan: Tachyon's protagonist.

At present one of Dr. Kreisler's graduate students, Michael Davis, is carrying the work further. He has lowered the limit by a factor of 30 and hopes in a further experiment to bring it down between 100 and 300 times. The tachyon experimental program at Princeton is "very low key," Dr. Kreisler stresses.

Meanwhile, Dr. Alväger has concluded from the failure to find charged tachyons that they probably aren't charged. "If they exist," he says, "they are most probably neutral."

He has an experiment going to look for neutral tachyons, but says: "We don't have any results we want to talk about yet." ◇