Moving Through Curved Spacetime

A Search and Discovery piece by Steven K. Blau (PHYSICS TODAY, June 2003, page 21) discusses Jack Wisdom's work showing that the position of an object can be changed when that object modifies its shape by extending and retracting across a Schwarzschild metric. Although this result may be new to theorists, it is already known to rocket scientists.

In a paper presented in 1990, I showed that by changing the length of a tether in a gravitational gradient—that is, in curved spacetime—one can modify the orbit, even to the extent of making the object climb away from the planet without expenditure of reaction mass.[1] In 1987, Manuel Martinez-Sanchez and Sarah Gavit had calculated similar results.[2] One can't push on flat spacetime, but in a region of curved space—or, if you prefer, tidal forces—one can use the difference in force to push against gravity.

References

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Blau replies: This letter speaks to issues considered by Jack Wisdom, so we contacted him for a response.

Wisdom comments: Geoffrey Landis is correct that, in Newtonian gravity, cyclic changes in the shape of an extended body can work against the gravity gradient to effect certain changes in the orbital parameters. For example, tidally induced shape changes of a synchronously rotating natural satellite can damp the orbital eccentricity of the satellite. However, he is incorrect in identifying that effect with swimming in spacetime.

Cyclic changes in the shape of a body in the curved spacetime of Schwarzschild geometry can lead to net translation of the body. The swimming effect depends on curvature; it does not occur in the flat space of Newtonian gravity. It is a geometric effect: The amount of the translation does not depend on how fast the shape cycle is executed. In the Newtonian effect that Landis cites, there is no translation of the center of mass for fast cycles. That the swimming effect is a relativistic one is apparent in its dependence on the speed of light.

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More on Early LEDs

In their article "The Promise and Challenge of Solid-State Lighting" (PHYSICS TODAY, December 2001, page 42), Arpad Bergh, George Craford, Anil Duggal, and Roland Haitz show a graph (page 43) of performance of light-emitting diodes as a function of time. The graph obscures the early history by suggesting that GaP:Zn,O devices first appeared in 1968, whereas by that time a number of manufacturers had them on the market. The breakthrough in gallium phosphide came in 1962 when Jerzy Starkiewicz and I discovered that good red emission required both zinc and oxygen to be present, and we mapped the appropriate concentration ranges.[1] That work allowed for the development of devices (we called them "crystal lamps") with sufficient reproducibility for manufacture. They were

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described in March 1962 in a journal that was restricted at the time, and a more complete description was given in the open literature later that year.[2]

Sample devices were sent to potential military users in May and June 1962. The response was enthusiastic, so toward the end of the year, a proper production line was set up in Phil Gurnell's semiconductor device group in the Services Electronics Research Laboratory in Baldock, England. One application was a film marker for Royal Air Force reconnaissance planes: An array of emitters put digital information about flight parameters onto each frame of the film. Obviously the array had to be small so that the marker used up very little of the frame. For that, the encapsulated lamps were 1/32 inch (just under 1 mm) in diameter and were mounted within the thickness of a printed-circuit board. That application was secret at the time but was later made public.

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Science vs. Religion: An American Pastime?

I wonder to what extent serious scientific discussions about intelligent design, creationism, and the like are just an American phenomenon. It seems that, outside America, nonreligious and religious people alike (including the pope, I venture) have less conflicting views. They have long understood that, in contrast to religion, science simply means a search for explanations of natural phenomena purely on the basis of physical and logical causation that is verifiable or falsifiable by observation and repeatable experiment, strictly without recourse to acts of God in whatever disguise.

That simple difference must first be made clear and then must serve as a guide in deciding what should and should not be taught in science courses. It would then become apparent that it makes no more sense to import religious beliefs into science than to devise and advocate nonreligious explanations for the Holy Trinity, original sin, or other articles of faith. In 1983, the television series *NOVA* aired an interview with Richard Feynman, titled "The Pleasure of Finding Things Out." A few of Feynman's comments from that interview would go a long way toward calming the waters.

> My interest in science is to simply find out about the world. . . . When we go to investigate it, we shouldn't pre-decide what it is we're trying to do, except to try to find out more about it. . . . Altogether, I can't believe these special stories that have been made up about our relationship to the universe at large because they seem to me too simple, too connected, too local, too provincial. . . . I can live with doubt and uncertainty and not knowing. I think it's much more interesting to live not knowing than to have answers which might be wrong.[1]

Reference

1. R. Feynman, in *The Pleasure of Finding Things Out: The Best Short Works of Richard P. Feynman*, J. Robbins, ed., Perseus Books, Cambridge, Mass. (1999).

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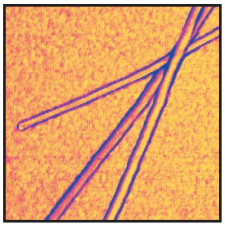
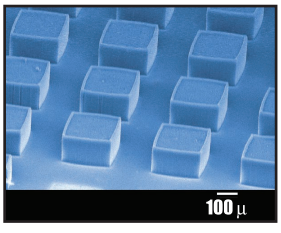


300nm AFM phase contrast image of SWNT ropes imaged with SWNT probe



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