Re: LIGO.

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- *From*: Tom Roberts <tjroberts137@xxxxxxxxxxxxx>
- *Date*: Fri, 09 Feb 2007 04:02:37 GMT

sal wrote:

> On Thu, 08 Feb 2007 17:44:25 +0000, Tom Roberts wrote:
>
>> The LIGO interferometer mirrors are held apart with constant spacelike proper distance by the inter−atomic force of their supports and beam pipes. The lasers measure the distance between the mirrors along a null geodesic. Their signal is the difference between the lengths of these two geodesics. They usually describe this as a variation in the distance between the mirrors (implicitly using c=constant all along the light path).
>
> Say what? Tom, would you be so kind as to expand that paragraph to include a definition of "distance" in each place where you used it, and please explain what you meant by the "length" of each of the geodesics which are being compared? I'm sorry, but as written, I didn't understand what you said.

The fields on earth are so small one can use a background Minkowski frame encompasing all of a given LIGO interferometer. As all of the interferometer components are supported against the earth's gravity, one can neglect it. All distances can be measured in this frame. An incoming gravitational wave distorts the metric from those Minkowski components, and the laser interferometer can detect that.

> Distance along a null geodesic could mean 3−d _coordinate_ distance of the endpoints projected into 3−d spacetime, _coordinate_ time difference, or proper distance (which is zero).

It is easiest to use the background Minkowski frame, as above. But one can also analyze LIGO in a coordinate−independent manner, which is more what I was thinking when I wrote this. Each pair of atoms maintains their proper spacing in their instantaneously−comoving inertial frame (that's what inter−atomic forces do); that is a separate frame for each pair. The no−gravitational−wave light beam is adjusted to give no output from the interferometer when everything is settled down, and this is modeled by computing the light's total phase difference over the path length by integrating over all those atomic−sized inertial frames (in practice one uses a coarser approximation), for each arm. The initial phase delay is equal for the two arms, because that is the condition for null output. When a gravitational wave comes by, those integrals will change (one arm increases in total phase delay while the other decreases), implying that the interferometer output will no longer be nulled.

Tom Roberts
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