2.7: Observer

ten thousand local witnesses

Observer defined

In relativity we often speak about the **observer**. Where is this observer? At one place, or all over the place? Answer: **The word "observer" is a shorthand way of speaking about the whole collection of recording clocks associated with one free-float frame.**[1] No one real observer could easily do what we ask of the "ideal observer' in our analysis of relativity. So it is best to think of the observer as a person who goes around reading out the memories of all recording clocks under his control. This is the sophisticated sense in which we hereafter use the phrase “the observer measures such-and-such.”

Observer limited to clock readings

Location and time of each event is recorded by the clock nearest that event. We intentionally limit the observer’s report on events to a summary of data collected from clocks.[2] We do not permit the observer to report on widely separated events that he himself views by eye. The reason: travel time of light! It can take a long time for light from a distant event to reach the observer’s eye. Even the order in which events are seen by eye may be wrong: Light from an event that occurred a million years ago and a million light-years distant in our frame is just entering our eyes now, after light from an event that occurred on Moon a few seconds ago. We see these two events in the "wrong order’ compared with observations recorded by our far-flung latticework of recording clocks. For this reason, we limit the observer to collecting and reporting data from the recording clocks.

The wise observer pays attention only to clock records. Even so, light speed still places limits on how soon he can analyze events after they occur. Suppose that events in a given experiment are widely separated from one another in interstellar space, where a single free-float frame can cover a large region of spacetime. Let remote events be recorded instantly on local clocks and transmitted by radio to the observer’s central control room. This information transfer cannot take place faster than the speed of light - the same speed at which radio waves travel. Information on dispersed events is available for analysis at a central location only after light-speed transmission. This information will be full and accurate and in no need of correction - but it will be late. Thus all analysis of events must take place after - sometimes long after! - events are over as recorded in that frame. The same difficulty occurs, in principle, for a free-float frame of any size.

Speed limit: c It's the law!

Nature puts an unbreakable speed limit on signals.[3] This limit has profound consequences for decision making and control. A space probe descends onto Triton, a moon of the planet Neptune. The probe adjusts its rocket thrust to provide a slow-speed "soft" landing. This probe must carry equipment to detect its distance from Triton’s surface and use this information to regulate rocket thrust on the spot, without help from Earth. Earth is never less than 242 light-minutes away from Neptune, a round-trip radio-signal time of 484 minutes - more than eight hours. Therefore the probe would crash long before probe-to-surface distance data could be sent to Earth and commands for rocket thrust returned. This time delay of information transmission does not prevent a detailed retrospective analysis on Earth of the probe’s descent onto Triton - but this analysis cannot take place until at least 242 minutes after the event. Could we gather last-minute information, make a decision, and send back control instructions? No. Nature rules our micromanagement of the far-away (Sample Problem 2-1).

Example 2.7.1: METEOR ALERT!

Interstellar Command Center receives word by radio that a meteor has just whizzed past an outpost situated 100 light-seconds distant (a fifth of Earth-Sun distance). The report warns that the meteor is headed directly toward Command Center at one quarter light speed. Assume radio signals travel with light speed. How long do Command Center personnel have to take evasive action?

Solution

The warning radio signal and the meteor leave the outpost at the same time. The radio signal moves with light speed from outpost to Command Center, covering the 100 light-seconds of distance in 100 seconds of time. During this 100 seconds the meteor also travels toward Command Center. The meteor moves at one quarter light speed, so in 100 seconds it covers one quarter of 100 light-seconds, or 25 light-seconds of distance. Therefore, when the warning arrives at Command Center, the meteor is 100 - 25 = 75 light-seconds away.

The meteor takes an additional 100 seconds of time to move each additional 25 light-seconds of distance. So it covers the remaining 75 light-seconds of distance in an additional time of 300 seconds.

In brief, after receiving the radio warning. Command Center personnel have a relaxed 300 seconds — or five minutes — to stroll to their meteor-proof shelter.

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1 Observer defined

2 Observer limited to clock readings

3 Speed limit: c
It's the law!
