Re: Mass vs distance

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Concerning:

> However, I do not grasp how this translates equivalently to the gravity
> case, which seems to call for a more exotic explanation.

I am not sure if you mean "why is this predicted" or "how can you visualize a
mechanism for the frequency shift" or "why do we believe this?"

I will say : Einstein *postulated* that the cases are connected by the equivalence principle* (EP). We believe in the EP (to the extent that we do)
because experiment seems to support this belief. As to visualizing a mechanism,
that is tricky and could be misleading. I will wait and see if this post helps before
I tackle that one.

The EP (you may know all this already): Imagine your elevator having no windows, and a scientist is inside doing experiments. In Case A, the elevator
is being smoothly accelerated in deep space; in Case B, it is sitting 'still' (relative
to some local large body) in a gravity well, with the field close enough to uniform
that tidal effects are too small to measure. Then the EP predicts that the outcome
of any* experiment she conducts will be the same in both cases.

For example, she is measuring gamma ray frequencies with the Mossbauer experiment, and finds that the frequencies are shifted upward when the source
is at the 'top' of the elevator, and the receiver at the bottom, for reasons you discuss
above − the elevator accelerates upward as the gamma ray crosses it, and she
measures a blue shift due to the velocity change in Case A. In Case B, the EP
predicts that she will see the same velocity change as Case A.

This unambiguous prediction is easily tested, and has been. The predicted shift
is seen. It is usually then interpreted as "Time runs slower at deeper gravitational
potential". I personally dislike this statement because I don't really know what
"Time runs slower" means − it seems to mean "all clocks run slower by the same
factor" and "light moves slower also, as measured by an uphill observer", and so on,
which makes it seem like particle masses are constant and c and h are relative to
observers. Since I prefer c=h−bar=1, I prefer to think of things a little differently, but
in any case, the operational predictions are unambiguous.

*There are three forms of the equivalence principle:

Weak EP:
The trajectory of a falling test body depends only on its initial position and velocity,
and is independent of its composition.

Einstein EP:
The outcome of any local non−gravitational experiment in a laboratory moving in an inertial frame of reference is independent of the velocity of the laboratory, or its location in spacetime.

Strong EP:
The gravitational motion of a small test body depends only on its initial position in
spacetime and velocity, and not on its constitution.

and

The outcome of any local experiment, whether gravitational or not, in a laboratory
moving in an inertial frame of reference is independent of the velocity of the
laboratory, or its location in spacetime.

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