Time-dilation for supernova in the case of tired light hypothesis.

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Abstract.

One of the most important confirmation of the Big Bang theory was the discovery of the time broadening of the light curve of the far supernovas (supernovas 1A, standard candles, at the distances around Z=1). From straightforward consideration in the complete absence of light scattering it can not be explained in any other way but by Doppler-like effect which in this case called time dilation and seemingly confirming the Big Bang. However, the hypothesis of tired light [1] also allows the light being diffusion-like scattered on travel from supernova thus allowing change in distance traveled and allowing corresponding time broadening of the light curve (the fastest photons goes straight path, later arrived those which due to multiple scattering – diffusion-like in perpendicular direction – first traveled away from direct line, than returned back, possible many times and thus got a big enough increase in distance to generate perceptible – few days- delays at arrival). Problem with this mechanism is that gives smaller time delays compare to time dilation directly observed [1]. The gravitational microlensing may be involved and due to additional change of distance, Shapiro effect and brightening some parts of the image of supernova (3 separate effects) will make the light curves broader and thus explaining the time dilation observed.

Introduction.

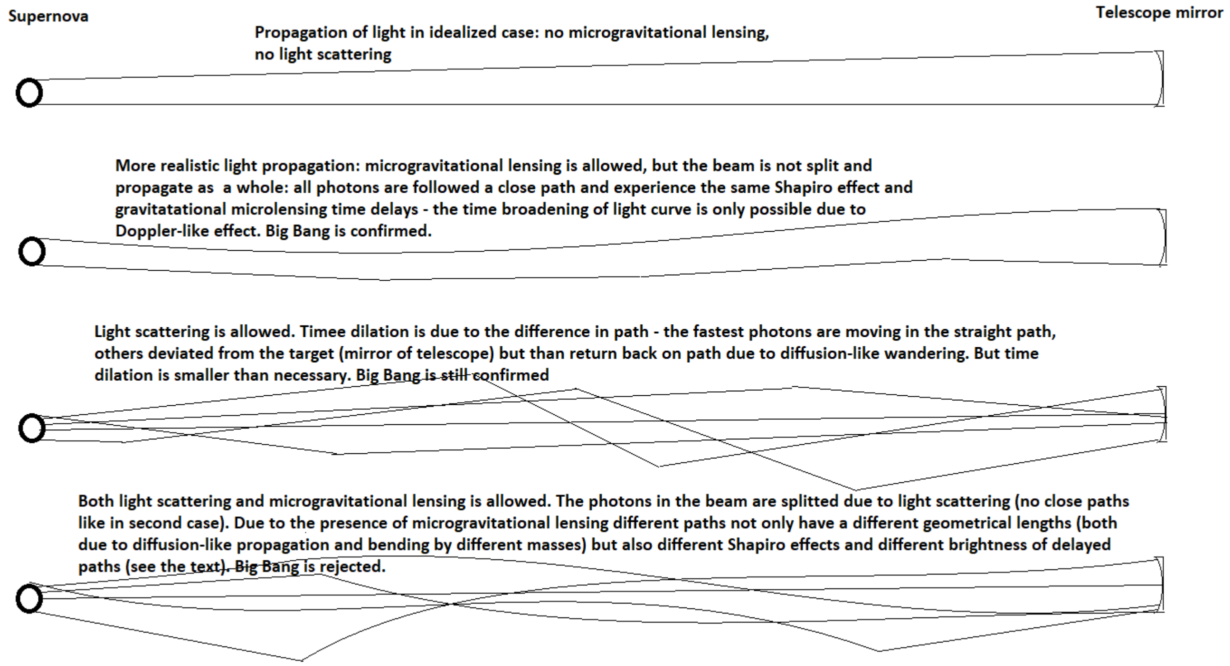
Discovery of the time broadening of the supernova type 1A (standard candle) light curves was instantly interpreted as a proof of the Doppler time dilation (the processes seems slower as a factor 1+z because the objects are moving away faster and faster as they are further from Earth). Indeed, up to z~1 (the best Hubble may do in supernova discoveries) the broadening of the light curve (time dilation) follows this simple law (broadening~1+z) and it was considered as a final confirmation of Big Bang. However, time dilation is also possible in tired light theory (the photons experience diffusion-like process and some will arrive few days later compare to the ones traveled the straight path). The real difference between the time dilation as inferred from Big Bang Theory or from diffusion-like tired light approach will be revealed at z~3 (and supernovas with z~3 are already detected by James Webb Space Telescope, so the complete light curve measurement may be on its way right now). This is because according to Doppler-like time dilation the law 1+z will persist and at z~3 the time dilation would be 4 times compare to z=0 (the light curve width for supernova type 1A must be around 100 days instead of usual 24 days at z=0); while for tired light the effect will be much smaller (light scattering quickly saturates with z [2]) and width should be only ~40-50 days (more than 2 times narrower). The difference between ~100 days and ~40 days is huge and for higher Z it will be even larger – while the supernovas at z~12 in Big Bang cosmology must shine bright around 260 days (more than half a year) the same supernovas for tired light idea will shine for ~60 days (see how fast the scattering curve saturates in [2]). Obviously if the time dilation will follow 1+z law up to those high z the Big Bang will be fully confirmed and any tired light hypothesis completely eliminated. Interestingly this observation is due in very close future – JWST is actually observing some supernovas at z=3.8 already [3] and this is only the beginning. But for right now it is necessary to explain how tired light may explain already observed time dilation for supernovas with z~1.

Main part.

The light curves of the supernovas are measured a lot, but for the further supernovas some unexpected factors may contribute to the width and make the curve broader what looks like time dilation. It may be influence of gravitational lensing on a scale smaller than generate the resolved multiple images (so called microlensing), with corresponding Shapiro effect and strong influence of the wavelength of the image taking detector since the light curve at one frequency is not the same as light curve for different light color (and red shift at high z makes it even more complex problem, it is necessary to recalculate light curve at different wavelengths back to z=0). It may happened that the time dilation is a result of multiple factors, which working together make the light curve broader than it is.

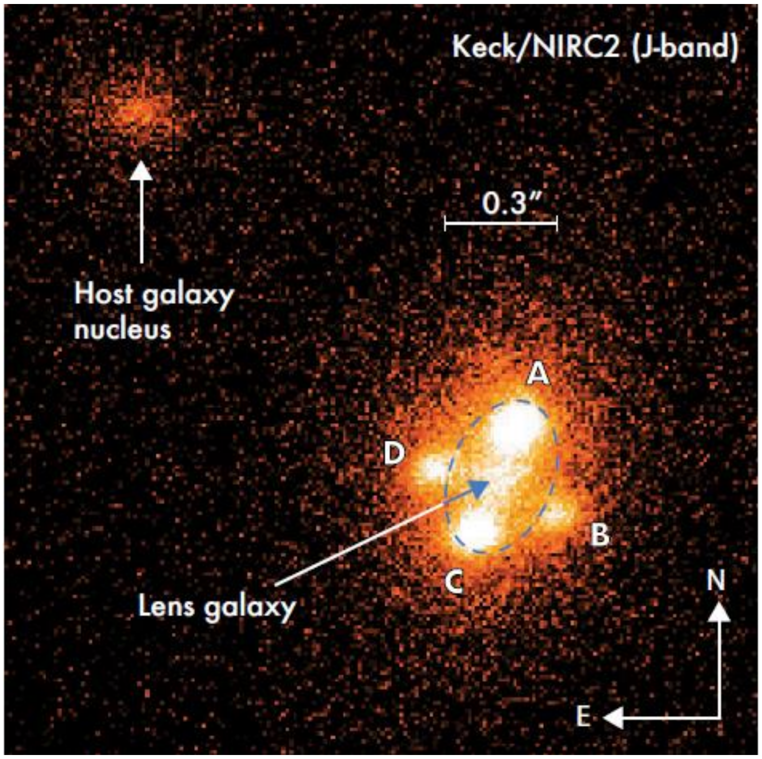
At first, the supernovas type 1A are not completely standard. They may be broadly divided into brighter ones and dimmer ones [4]. Because of the range of white dwarfs leading to explosion, some supernovas type 1A are brighter and some are dimmer (but both are type 1A because of spectroscopic features). What is very important for time dilation the brighter supernovas type1A are fading slower (not very much but well resolved by the light curves). Since the brighter supernovas are easier to spot at the high z (for Hubble supernovas at z=1 are already approaching the limit of detection), the far supernovas have a **selection bias** toward the broader light curve.

Another important difference between the modern model of the light propagation (no light scattering is allowed) and tired light hypothesis is in the way the light propagating from supernova experiences gravitational bending. The real size of supernova type 1A at the moment of the maximum brightness (they usually discovered around this moment) is relatively small compare to typical interstellar distances (distance Sun to Alpha Centauri is 3.8*10exp(16) meters). The real size of supernova is only 2-3 light days at maximum brightness - something like 3-4.6*10exp(13) meters [3] (just around 50 times larger than the giant red stars with size up to 10exp(12) meters [5]). For this small size the beam without light scattering may be bent by gravitational lensing but as a whole (the right and left parts of the beam are experiencing the same path and the same time delay both Shapiro effect and geometrical).



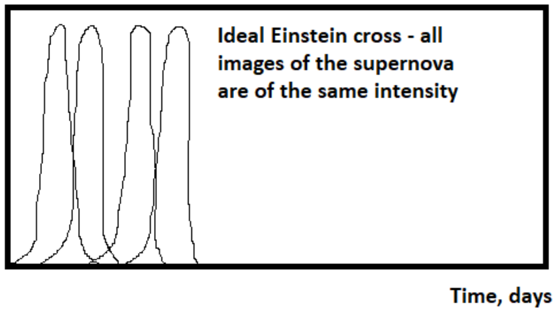
Due to the presence of microlensing the real image of the supernova at Z=1 and beyond would be consisting of many very small dots (provided the resolution of the telescope is 100 times better than Hubble). This is because the smaller masses (compare to strong gravitational lensing which generates visible Einstein cross) will generate many Einstein crosses but they all blurred together due to lack of the resolution. Interestingly the time dilation may be actually observed even in the case of the absence of light scattering and absence of Big Bang (no Doppler-like effect is necessary) – because the already observed Einstein crosses are demonstrating huge difference in time of arrival of light for 4 different images (up to 180 days) and possibly smaller, hardly resolved Einstein crosses will give the time difference comparable to the observed time broadening of the supernova light curves (if Einstein cross is not resolved, all four images will give actually one but photons from different paths arrive at different time, the observed light curve is actually of sum of 4 light curves time shifted with respect to each other – it will inevitably be time broadened).

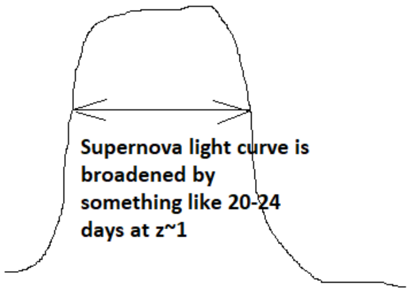
In [6] the excellent example of hardly resolved Einstein cross is shown with lensing galaxy much weaker than the supernova images:

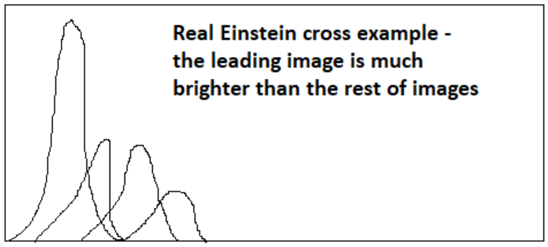


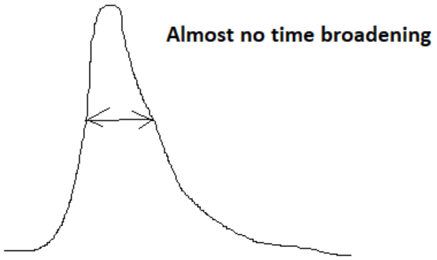
If the resolution of the telescope would be just a little worse, this supernova would looks like one image. But it would be actually consisting of 4 overlapped images with different times of arrival and thus the observed light curve would be much broader than each of the constituents. One of the explanations of the supernovas huge visible angular sizes [7] (up to 6 times larger than diffraction limit of the telescope at z=3 as observed by JWST) which **preserves the Big Bang is** exactly this one – the real image is merely the superposition of multiple Einstein crosses due to weak gravitational lensing (unresolved because the resolution of JWST is limited). In this case however the time broadening of light curves (seemingly confirming Big Bang due to Doppler like effect) must be even more pronounced – first because of Doppler effect (proportional to 1+Z) and second due to overlapping of different images which have different paths and Shapiro effects (proportional roughly to sqrt(Z)) – in total the time broadening of light curves would be so big that the supernovas already at z=3-4 would shine for many months. Such enormously large time dilation may be already dismissed – even preliminary images of JWST (for z~3) made with time separation of months are not showing such ultra-persistent supernovas.

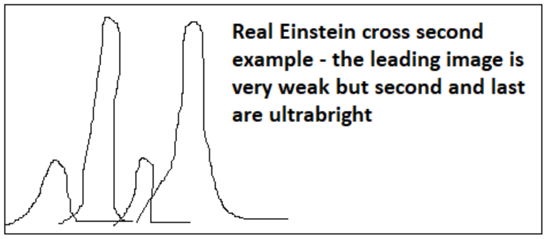
The last effect which may contribute the most (Shapiro effect is of course present but usually considered as being around 10% of the time delay due to elongated path) is the different brightness of the different constituents of unresolved Einstein cross. Indeed, this is easy to see on the picture above – no Einstein cross is ideal, usually one component is very bright and one is very dim. If the Einstein cross is unresolved, this may contribute strongly to the observed time broadening of the supernova making it very broad or very narrow (almost as narrow as without any gravitational lensing effect). It also is different for different wavelengths, making matter even more complicated. The great review on this topic is [8] where the effects of microlensing for supernovas at z~1 were estimated as leading to around 10-14 days difference in time broadening (actually enough to explain the “time dilation” for supernovas even without any Doppler-like effect).

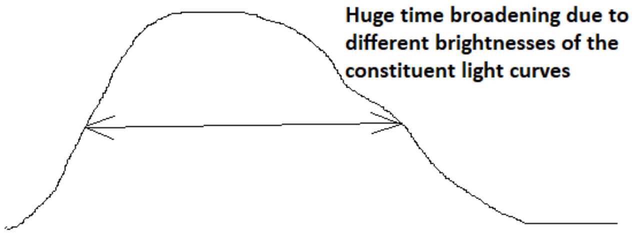












This effect is mainly contributing to big scatter of the observed time dilations and should be averaged on multiple observations of supernovae. Unfortunately to make such a statistics even at z~1 thousands of supernovae are to be recorded with light curves (unbearable task even for Hubble plus Earth based telescopes). And for JWST so far only observations of the supernovae are made (and no reported light curve is measured). Meanwhile this effect by accident may generate extremely broad in time light curve for supernova, seemingly confirming Big Bang, but in another accident may completely reject Doppler-like effect – the scattering of data may be big. Published data on light curves indeed confirmed the big scattering in observed "time dilations" for supernovae at z~1, but whether it is due to such brightness difference mechanism (of unresolved Einstein crosses) or due to inevitable experimental errors is not clear at this time.

Conclusion.

While the initial estimation of the time broadening of the light curve of supernova gave a smaller than necessary value (4.4 days instead of 20 [1]) if other effects are taken into consideration the tired light hypothesis may create big enough value. As it is a typical case in many complex scientific issues, only direct experiment may differentiate the Big Band and Tired Light in the question of "time dilation". Big Bang and Doppler-like effect must generate at least 1+z time broadening (or may be even larger if microlensing and unresolved Einstein crosses are taken into the consideration), while Tired Light must generate much modest time broadening approximately like sqrt(z) (for more precise formula see [9]). Already for z~3-4 (actual supernovae observed by JWST in 2023-2024) the difference is huge and even with discussed brightness-generated errors should be easy to differentiate. This experiment (direct measurement of light curves for supernovae at z~3-4) may be considered as one of the simplest and possible at the present time (beginning of the 21st century) ways to New Physics (for more proposals see [10-11]).

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