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A2_9 Andromeda's trip through time

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Abstract
In the sci-fi tv series 'Andromeda' a ship travels 300 years into the future after 3 seconds from the ships perspective. This paper uses the conditions stated in the show to determine that the ship will experience such time dilation when it lies at 9.3599×10^{-6}m from the event horizon and that this would not be possible to achieve without losing the ship permanently to the black hole.

Introduction
In the series 'Andromeda' the titular starship and its commander, Dylan Hunt, end up travelling into the future after getting too close to a black hole in the opening episode. Numerically it is stated that in 3 seconds upon the Andromeda Ascendant that 300 years have passed in the rest of the universe [1]. It is also claimed that this happened due to being trapped on the event horizon of the black hole until retrieved by another ship at a later date. This is not possible as at the event horizon, or Schwarzschild radius (r_s) the escape velocity is the speed of light and would require infinite energy to achieve. This paper will investigate how close to a black hole a ship would actually have to be to achieve such time dilation and the feasibility of the show's suggestion.

Theory
Time dilation can be described by the Schwarzschild metric [2] which describes space around a spherical, non-rotating and neutrally charged mass. It is given by

$$c^2 d\tau^2 = (1 - \frac{r_s}{r})c^2 dt^2 - (1 - \frac{r_s}{r})^{-1} dr^2 - r^2(d\theta^2 + sin^2(\theta)d\phi^2) \tag{1}$$

using polar coordinates and where c is the speed of light, dt is the change in coordinate time and d is the change in proper time. The ship is described to be trapped in place during this dilation effect and as a result it can be assumed that $dr = d\theta = d\phi = 0$ which simplifies (1) to

$$c^2 d\tau^2 = (1 - \frac{r_s}{r})c^2 dt^2 \tag{2}$$

which can easily be arranged to give the final equation to produce the radial distance of the ship to the black hole for a specific time dilation.

$$r = \frac{r_s}{1 - \frac{d\tau^2}{dt^2}} \tag{3}$$

The final component required to begin calculation is that of the Schwarzschild radius which is defined as

$$r_s = \frac{2GM}{c^2} \tag{4}$$

where G is the gravitational constant and M is the mass of the black hole. The setting described in the episode implies that a solar system was being threatened by a black hole and as such it would be reasonable to assume a stellar mass black hole of 10 solar masses or 1.9891×10^{31}kg. This produces a radial distance 9.3599×10^{-6}m from the event horizon.

Discussion
The small distance from the event horizon brings up some interesting points. The first is that the original statement in the episode that the Andromeda Ascendant was resting on the event horizon was almost correct with a negligibly small difference in position. Even so the statement that an object can rest on the event horizon is never an accurate statement so this cannot be justified. The next is that the results

clearly show that one assumption made from the show cannot be true. With such a small gap till the event horizon even the smallest motions would fling the ship beyond the point of no return so it could not have been at that position and still been recovered for the three seconds it remained there. Another point is that the Andromeda Ascendant is over a kilometre long and as such could not be positioned at this point without sections being within the event horizon, the same could be argued for a human as well as the distance is so small relative to our sizes.

Conclusion

While there is a point at which the Andromeda Ascendant could experience the stated time dilation and still be recovered, this point is 9.3599×10^{-6}m from the event horizon. With such a small gap there is no way the Andromeda Ascendant could have been placed at that point even for the mere 3 seconds proper time that the vessel was stated to be there and therefore couldn't have experienced such time dilation by gravitation and still been recoverable.

References

[1] `http://andromeda.wikia.com/wiki/Andromeda_Ascendant` accessed on 21/11/2012.
[2] `http://casa.colorado.edu/~ajsh/schwp.html` accessed on 21/11/2012