

## Re: Conservation of momentum (and a weird space drive)

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**From:** Tom Roberts ([tjroberts\\_at\\_lucent.com](mailto:tjroberts_at_lucent.com))

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Joe wrote:

> *Tom ROberts wrote:*

>>*First start in the context of Newtonian mechanics. Imagine an isolated planet with mass  $M$  having a tall tower. A small mass  $m$  is initially at the base of the tower. It is carried up the tower and then dropped back to the base (bring the carrying mechanism back to its original state). Initially both  $M$  and  $m$  were at rest in some inertial frame, and afterward they are again at rest at the same position in that same inertial frame.*

>

> *Okay. But this is because the force on the falling ball is the same and opposite to the force on the planet. If it weren't, this wouldn't happen. And also are  $M$  and  $m$  in the same position? This is like two people throwing a ball in a canoe. The canoe moves! But then it stops. The center of mass is in the same position. But the canoe isn't!*

Yes. That's why I started and ended with everything ( $m$  and carrying mechanism) in the same state (position) on the planet. That means  $M$  and  $m$  end up in their initial positions in that inertial frame.

Have your canoeists throw the ball a second time so it is back where it started relative to the canoe, and the canoe and canoeists and ball move back to where they started (in the water). I'm neglecting friction and other minor effects here.

>>*Now instead of a small mass  $m$ , let's consider a flashlight which starts charged up at the base of the tower, is carried to the top, shines down onto the surface of the planet (and discharges), and is then carried back down (after discharging). Let me assume the light beam is completely absorbed by the surface, and is turned into heat.*

>

> *Already here again I'm confused. This is like the solar sail question. You have a solar sail, and you shine a light on it, if all the energy of the light gets converted into heat, how does it move?!*

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If the source of the light is attached to the sail it does not move (just like if the wind on a sailboat is from a fan mounted on the boat the boat does not move). If the source of the light is not attached to the sail (e.g. sailing away from the sun), then even if the light is 100% converted to heat in the sail the sail is accelerated away from the sun. But if the light is 100% reflected the sail is accelerated by twice the amount, and you don't have to get rid of the heat.

> *The energy in a coherent bulk motion in one direction isn't there,  
> it's converted to random thermal motion of the sail.*

The heat is vastly smaller than the binding energy of the sail, so the sail retains its shape and moves as an object. But it gets hotter, and you do need to deal with that — the only thing you can do with the heat is to re-radiate it; if you re-radiate it isotropically you will reduce the efficiency of the sail even more, so it is best for such a solar sail to be as reflective as possible (which is equivalent to re-radiating the heat back towards the sun).

> *You don't need  
> gravity to make a space drive then. You just need to be in a box in  
> outer space, where one wall is such that light incident on it is  
> directly and ONLY converted into heat. Then you can just stand on one  
> side, shine light in one direction, it kicks you and the box in that  
> direction, and on the other it gets converted into heat. Is this idea  
> right?*

No. Just as in my gedanken above, your box will not move.

>>*As we are  
>>still in the weak-field approximation, gravitational radiation can be  
>>neglected, as can other things like the variations in stress of the  
>>tower. The above conclusion is then unchanged -- the position and  
>>inertial frame of the planet are the same beforehand as afterward.  
>  
> It's good that we can neglect this GR radiation, because I don't know  
> what the hell it is! But this is where I'm lost, and you have to go  
> slower. Why is it the same?*

In comparing this gedanken (flashlight, weak fields) to the previous one (mass m, weak fields), nothing significant is changed except the "object" dropped back to its original position wrt the planet is light, not the mass m. In GR that difference is not important, so the conclusion for this gedanken is the same.

> *In fact, why isn't there a net velocity  
> of transfer in one direction!*

Loosely, because the transfer of momentum balances out (this is loose because it depends on the weak-field approximation to GR).

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>>In your scenario you forgot to include the change of internal energy in  
>>the light source, and the implications of that. In my discussion above,  
>>if one does not carry the flashlight up/down and only considers the time  
>>during which it discharges, then there is clearly energy transfer from  
>>the top of the tower to the bottom. That cannot be neglected, and tends  
>>to move the planet+tower+source in the opposite direction of the effect  
>>you do mention (blueshift of the light).  
>  
> Now this is interesting! Do you mean that if just considering a  
> tower+planet+source all stationary, and you're at the top, and you  
> shine the light towards the planet, there is a net motion in the  
> direction of the light?

No. re-read this gedanken -- it shows there is no motion after you bring the light source back to where it started. In a "closed" system of planet + mass + flashlight you can make the center of the planet move by moving m or light within the closed system. But to impart a net velocity to the system you must eject some energy or mass from the system.

Tom Roberts tjroberts@lucent.com