Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *How general relativity can improve your love life.*

1. Choosing the right moment.

Next time you ask someone out to dinner – it's important to remember that you live in a four dimensional universe. Even if you plan to meet at the corner of Smith Street, running north to south, and Jones Street, running east to west, in a restaurant that's up on the 5^{th} floor, it's very likely that you will both completely miss each other unless you also mention where you are going to meet in the 4^{th} dimension – that is, time.

Given how we routinely conduct our daily lives in 4 dimensions, it's strange that the concept of a four dimensional space-time universe is so alien to us. Living on a massive object at the bottom of a gravity well may have something to do with it.

2. The gravity of the situation.

Between a scattering of sun and planets, the universe contains huge tracts of what I am going to call *fairly empty space*, being a dark, almost vacuum – with a shadowed temperature of less than 4 Kelvin, a few random photons and protons and only the faintest hint of microgravity. Most places in the universe are *fairly empty space*.

Homo sapiens casually expressed law that what goes up must come down doesn't apply in most places in the universe. In most places in the universe, what goes up, goes up. On Earth, the tendency of upwardly-mobile inanimate objects to reverse course in mid-flight and return to the surface is more than a bit unusual.

There's further strangeness to be had if you go along for the ride. If you launch in a rocket along the kind of parabolic curve that would be followed by a cannonball fired up from the Earth's surface, you will be pushed back into your seat by G forces on the way up but as you reach the top of the curve and then start to fall back down again you'll be weightless – and even though the rocket appears to be accelerating all the way down to the surface, you will stay weightless until you hit the ground.

So, next time someone tells you that acceleration always causes G forces, tell them to go jump out of a plane.

3. Making your move.

Out in *fairly empty space*, acceleration does always cause G forces. Pick a spot about 100 million kilometres out from Neptune and you're still just within the gravity well of the Sun, but in a place where the only force stronger than microgravity is really strong microgravity. Fire your rocket now and there will be an initial acceleration pushing you back in your seat which will taper off to a constant velocity when you cut the engines and from there you will experience weightlessness.

It's just like following the parabolic trajectory on Earth that had you being pushed back in your seat while your rocket blasted you upwards and then experiencing weightlessness as you fell back down, weightless until the very end when you slammed back to the surface.

Of course out here, 100 million kilometres from Neptune, once the rockets are switched off, you are just going to keep on going and going at a constant velocity, feeling weightlessness… That is, until you hit that brick wall we have built out in space for the purpose of this podcast.

Hitting that brick wall will kill you just as effectively as hitting the Earth's surface back home.

4. It feels like falling.

If you've been following the story so far you might be wondering what it is that makes you apparently accelerate when you fall towards the Earth – even though you experience none of the effects of that acceleration.

The key word in that sentence is apparently. You don't feel the acceleration when you fall towards the Earth, and apart seeing the ground rushing up towards you, there will be nothing to suggest to you that you are accelerating. It's only someone watching you from a distance who remarks – 'hey look, you're accelerating'. As far as you are concerned, you're not.

It's as though what seems like a straight line in *fairly empty space*, gets bent into a parabolic curve inside Earth's gravity well.

Some people, and here I am talking about some people with Nobel prizes, think that gravity is bunk. General relativity proposes that massive objects warp space-time. The standard visual representation of heavy balls creating depressions in a rubber sheet is an imperfect explanation since it's really four dimensional space-time that is being warped – but it does give you the general idea.

The suggestion that General Relativity somehow supersedes Newton's Laws of Motion is also an imperfect explanation. Relativity really just defines a new environment within which Newton's Laws can continue to operate. A good example is the First Law that states *A body persists in a state of rest or in a state of uniform motion unless acted upon by an external force*.

A body travelling at a constant velocity out in *fairly empty space* will just continue along a straight line, potentially forever, in the absence of external forces or brick walls. However that straight line will lead you straight into disaster if the space-time continuum it's running through is warped by the presence of a planet.

5. Doing the math.

The apparent acceleration that you don't feel while falling to your doom is the result of your constant velocity, measured as distance over time, being translated into an environment where distances are shorter than they used to be, squeezing your straight line into a curve and progressively adding to your speed – at least from an external observer's point of view.

The apparent effect of gravity on time also has an accelerating effect on your speed – at least from an external observer's point of view. Since clocks appear to run slower in a gravity field, the distance covered per hour out in *fairly empty space* translates to a distance covered in less than an hour when you're near a planet. Arguably, you are still moving at a constant velocity from point A to point B – it's just that you get to point B a lot faster than you would have out in *fairly empty space*.

OK, so I may have glossed over some fairly complex mathematics here – and provided an imperfect explanation myself – but you get the general idea.

6. Making your own destiny.

Newton's First Law holds all the way down through your plunge to destruction. There is no external force acting upon you. Gravity, smavity. As far as you are concerned you're still just following a straight line at a constant velocity – it's just that someone put a planet in the way.

In fact, your only chance of survival in this scenario is to evoke an external force, like firing your retro rockets. This moves you off that straight line to destruction – and you can make your own destiny from there. And not before time, remember you've got a hot date at that restaurant. Wear something nice, get them talking about themselves and look like you're making an effort. You'll do fine.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website that helps you see through a glass, cheaply. No ads, no profit, just good science. Bye.