

## A culinary story (personal and biased)

My favorite Chinese restaurant in London is [New City](#) at [185 Battersea Park Rd.](#) They make *the* best deep fried spicy squid ever known to mankind. The recipe, in old Mandarin, looks like this:

獨我發誓全讓你看飽絕不豪飽費載小, and then add 數來.

Absolutely delicious. And they haven't changed the recipe since November 1998, as far as I can tell. But it is still a bit of a mystery.

So, I decided to play Chinese and do some reverse-engineering, by trying a traditional Deep Fried Squid Rings (Calamari) Recipe offered [here](#). Total failure: the Italian bread crumbs didn't stick to the squid. Tried with non-Italian bread crumbs -- same result. I don't need to know the physical and chemical details of the entire process -- just a working recipe, FAPP.

Finally, I gathered some courage (that is, I accepted defeat) and asked the girl (I know her as Ms Lia -- charming girl with beautiful smile) who was delivering the fried squid about their secret. She gave me a very smart hint (I wouldn't like to share it here), and now I too can cook *the* best deep fried spicy squid ever known to mankind.

Which reminded me of how people explore, study, and teach GR. You face a '[deep fried squid](#)' made by Mother Nature, and try to apply some common-sense recipe for your reverse-engineering. If you believe have succeeded, at least to some extent (it depends on how much oil you'd accept to eat with the squid), you publish your findings in peer-reviewed journals, and eventually write up books, like [Steven Weinberg](#). Your 'comma to semicolon' recipe sounds like this (p. 106):

"Write the appropriate special-relativistic equations that hold in the absence of gravitation, replace  $n_{mv}$  with  $g_{mv}$  and replace all derivatives with covariant derivatives. The resulting equations will be generally covariant and true in the absence of gravitation, and therefore, according to the Principle of General Covariance, they will be true in the presence of gravitational fields, provided **always** that we work on a space-time scale *sufficiently small* compared with the scale of the gravitational field."

Trouble is, the meaning of '[sufficiently small](#)' is sheer poetry. Unlike cooking, you need to know [the details](#) of [the whole story](#). That is, you need to know what happens in *the infinitesimal neighborhood* of an abstract "point" in the cases of (i) flat background Minkowski space and (ii) no background **at all**. [Huge difference](#).

Locally -- in *the infinitesimal neighborhood* of an abstract "point" -- it looks as if there were no difference between gravitational "force" and inertial "force" (cf. [D. W. Sciama](#)), as we all know from our experience with falling [elevators](#).

But in case (ii), what looks like "local" stuff is actually [quasi-local](#). And if you want to "prove", with some smart reverse-engineering, that you are indeed dealing with [strictly positive mass](#), and if you want to study the origin of inertial reaction "forces" pertinent to this positive mass, you need to include 'the whole spacetime', up to its non-trivial "[borders](#)" at which the universe is "spatially self-enclosed" [[1](#)]. The mundane comma-to-semicolon-

like recipes won't work, because the mechanism by which matter 'there' influences inertia 'here' does **not** take place on a spacelike hypersurface, yet there is no violation of relativistic causality. Let me try to explain.

To understand the crux of GR, recall Einstein's Principle of General Covariance: it "takes away from space and time the last remnant of physical objectivity" (Grundlage der allgemeinen Relativitätstheorie, *Annalen der Physik* 49 (1916) 769-822).

What is meant by 'physical objectivity'? It is the case (i) above: you may imagine some fictitious flat background space, such that you can pick some abstract point from it, and find out that there has *already* been a *perfectly local* value of physical fields **locked** on it. It is like a colorful painting on a canvas -- every point from the underlying canvas is painted with its unique color.

But in case (ii), there isn't such fixed background. Think about the values of physical fields at particular "point" from the spacetime in GR as the changing color at particular points from the skin of a *perfect octopus*.

What is *the* intrinsic color of an *octopus*? It does have a skin, but **the only way** you can see the "skin" is *through* its color, that is, at the **instant** (cf. Escher's drawing below) at which it takes on some particular *dynamical* color. It doesn't possess some pre-existing color **locked** on particular pixel-point from its skin, as in case (i).

The color of 'the skin *per se*' of our octopus has become '*potential reality*'. Its **real** "color" is actually color-*less*. It is UNSpeakable, like *Platonic ideas*. It is indeed **real**, only belongs to a wider form of reality -- *potential reality*.

Going back to the analogy with the deep fried squid: in case (i), the point-like "colored breadcrumbs" are locked on every point from squid's skin, while in case (ii) these "colored breadcrumbs" have become *dynamical*, in the sense that they **determine** the "skin" (spacetime) at each and every instant from the *Arrow of Space*.

Any time we look at the world around us, we see a particular snapshot from a dynamically colored "GR octopus". To uncover its *intrinsic* color-less "skin", we need to dwell on *Quantum Theory*.

Surely there must be something that sticks the fleeting **quasi-local** "colored breadcrumbs" onto the "skin" of our octopus: the universe as *ONE*. If we think of a *school of fish*, it will be 'the school of fish as ONE' that determines the quasi-local state/color of each and every quasi-local fish. In GR parlance, "(1) Spacetime geometry steers fields and matter. (2) In turn, the combined field-plus-matter momentum-energy steers the geometry" (*Ciufolini and Wheeler, p. 270*). Such inherently non-linear *bi-directional* negotiation between every *quasi-local* fish (matter) and 'the school of fish as ONE' (geometry of space) is depicted with Escher's drawing below.



We can't see the "negotiations" between the two sides of Einstein field equation, however. Our wristwatch reads a *continual* chain of **already**-completed negotiations. Hence if you consider just one frozen snapshot from the color-state of our GR octopus, and try to extend it into the "[future](#)", you will [inevitably fail](#). In order to recover the genuine dynamics of GR, you need to "hold onto" the UNSpeakable *reference fluid* of GR, which exists as [potential reality](#).

Most importantly, we can explain the origin of inertia: Mach's reference frame of 'fixed stars' (cf. [Mach 11](#)) is replaced with the *reference fluid* of GR (if the latter can be accessed with a human brain, it may be possible to cancel out the inertia of mass *almost* completely).

To sum up, we can restore the *physical objectivity* of space and time, albeit not in the way imagined by Einstein, and (perhaps) extract [energy from "empty" space](#) (also known as "dynamic dark energy of [we-do-not-know-it](#)").

First, let's see what would happen if the energy *density* of the gravitational "field" were localizable, as in the case of electric field, contrary to MTW, [p. 467](#). The gravitational "field" is inherently **self-acting**: "gravity carries energy and is thus a source of *more* gravity. In this sense gravity differs fundamentally from the electric field, which does not carry charge and thus is not the source of more electric field" ([Ron Adler](#)). So, if the energy *density* of spacetime (the gravitational "field") were localizable on a "point" that belongs to the spacetime **itself**, we would be able to integrate such 'energy density points' (and compute derivatives, [Bjoern Schmekel](#)) to find the **pure** gravitational energy content of a **finite** volume of space, and then unravel the origin of the so-called "[dynamic dark energy](#)": it would be a **self-acting** faculty of the spacetime itself, exposed to the physical world, and won't be "dark" anymore. Moreover, the dynamics of such *exposed* gravitational energy would single out an absolute reference frame associated with 'the whole universe', with spacetime metric that is being "expanded" **by itself**, just like the way [Baron Munchausen](#) managed to lift himself and his horse out of the mud by lifting himself by his own hair.

Not surprisingly, the gravitational energy is of *dual* nature: both local and non-local, or in brief 'quasi-local'. It springs from 'the school of fish as ONE' and gets smuggled into all [quasi-local fish](#), camouflaged as "their" [self-force](#). Which is why some (otherwise smart) people call it "[dark](#)". Oddly enough, this "dark" component is actually made of two tug-of-

war effects ([CDM vs DDE](#)), which were vital for the genesis of our universe, but this is already a bit difficult to explain.

Point is, did you expect to discover a *perfect* "octopus" in your GR textbooks? And you didn't at all expect that your good old wristwatch may be reading a *bona fide* [quantum-gravitational](#) phenomenon -- a *continual* chain of [already-completed](#) and [already-linearized](#) negotiations between the two sides of Einstein field equation, or did you?

Not sure? Find your Ms Lia and ask, *very* politely, for advice.

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**1.** Albert Einstein, *Essays in science*, Philosophical Library, 1934, [p. 52](#):

"In my opinion the general theory of relativity can only solve this problem [of inertia] satisfactorily if it regards the world as [spatially self-enclosed](#)."

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