OF GRAVITATIONAL WAVES AND QUANTUM COOPERATION

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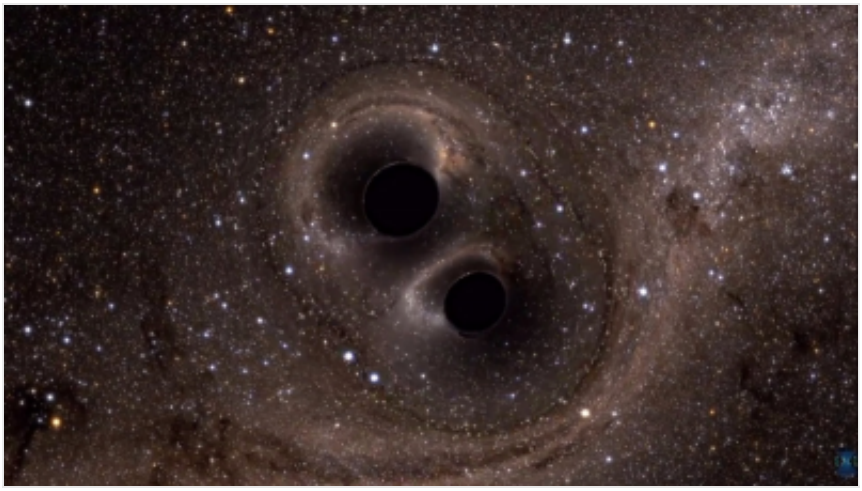
by Tasneem Zehra Husain



There's no doubt about it: conflict commands attention.

Perhaps it made sense as an evolutionary strategy. Historically, the conflicts we would become aware of were those that occurred in our immediate vicinity, and as such, could have life or death consequences. The penalty for ignoring such a scenario, in favor of something more pleasant, could be fatal. Those of us who attuned their ears to sounds of eminent disaster lived longer.

Focusing on potentially explosive situations might have served us well in days gone by (and of course it is still a necessary reflex in many scenarios) but continuing to do so, in our increasingly connected world where the news rains down on us incessantly, means that we are subjected to a barrage of negativity all day long.

The sensational headlines that follow us everywhere, the incessant chorus of strife and war and disaster that closes in on us, is not because the world is going to hell in a hand basket, but because the media giants who bombard us with soundbites around the clock know that conflict has the ability to arrest us in your tracks, to force us to pay attention. Life isn't any harder now than it was a century ago, in fact in many ways it is much easier; scholars have argued that the world is actually becoming a better, more just place; but since we hear mostly about what goes wrong, both in our backyards and at the other end of the globe, each of us is burdened with a planet's worth of woe. And as a result, we are growing increasingly weary.

Perhaps it is to counter this feeling of fatigue and ennui that a new wave of positivity has started rippling through the world. There is a slow, but growing, trend towards ‘feel-good' stories, reminders that in this apparently doomed world, there are surprising moments of grace. This is a movement I can completely get behind. Attention works such that it multiplies that which is focused on; stories of reconciliation, of people helping each other, of wounds being healed and problems solved - these act as a balm for our minds and our souls.

Funnily enough, what prompted these philosophical musings today was the thought that Nobel season is upon us. Just over a week from now, on the morning of Tuesday, October 5th, someone (or three someones) will be getting that fabled call from Sweden. Of course we can't ever say for sure, but there are years when the choice seems far more obvious than in others. I think it's fair to say that the international physics community would be quite shocked if the prize was not awarded for the detection of gravitational waves, and Rainer Weiss, Kip Thorne and Ronald Drever did not end up wearing this year's laurels.

Shortly after they rippled through our little patch of spacetime, gravitational waves began rippling through the media. The signal they generated in our common consciousness is far far stronger than the signal registered by LIGO (the Laser Interferometer Gravitational wave Observatory). Much has been written about this ground breaking achievement. The physics behind gravitational waves has been expertly expounded; we have heard about how they lay latent in the equations of general relativity for a century, and how many - including Einstein himself - doubted that this theoretical possibility would be realized by Nature; we have heard that the detector is a marvel of technology, engineered with such incredible precision that it takes quantum effects into account. (After all, if we want to know when the size of the already inconceivably small proton fluctuates by one part in one thousand, we have to contend with bizarre quantum rules like Heisenberg's uncertainty principle, and compensate for the infinitesimal 'push' exerted on a mirror by a ray of light. These quantum conundrums sound like they belong in science fiction, but due to the ingenuity and persistence of the thousand-strong team behind LIGO, we now have the skills to resolve them.) We have heard all this and more, but throughout all these stories runs an undercurrent of tension; whether it is the internal conflict of a scientist who finds it difficult to fully accept the implications of his own theory, the drama of surmounting almost impossible odds to build a highly complicated machine, or the intellectual and emotional conflicts we endured in the decades it took for Nature to answer a question we had posed.

To be fair, there is a parallel thread of stories celebrating the triumph of having opened a new window onto the night. It is as if, in addition to seeing the pinpricks of light on the sky, we can suddenly hear the stars sing. Sounds that emanate from familiar celestial bodies might be nice to hear, but what is particularly thrilling is that we can now listen for the voices of things that light does not illuminate - objects that thus far, lay hidden in the dark. Black holes, for starters, and who knows what else. It's hard to

interpret these stories as conflict-driven - unless you really want to stretch a point - but they are strongly rooted in drama and mystery, elements that exercise a similar magnetism attraction as far as human attention is concerned.

But after all this is told, a story still remains; a subtle tale of cooperation between two theories that are usually portrayed as being at loggerheads with each other. Quantum mechanics - which describes the behavior of the minuscule - and general relativity - which describes the nature and behavior of gravity - are the crowning achievments of twentieth century physics, and that stature seems to be all they have in common. Quantum mechanics was accepted only grudgingly, even by those who helped formulate it, and decades after its widespread adoption, still remains highly non-intuitive. General relativity, on the other hand, is considered extremely elegant, deeply beautiful, and almost seems inevitable in hindsight. The two theories lie poles apart not just because of the way they were received by the world, but because the philosophies at their core are wildly different. Reality, as conceived of in general relativity, is smooth; quantum mechanics declares it to be choppy. Quantum mechanics treats spacetime as a fixed stage upon which the fundamental particles and interactions play out; general relativity insists that spacetime is dynamic and responds to whatever occurs within its folds. In many ways and for many reasons, the two schemes contradict each other; they cannot both be true - or at least, neither of them can capture the whole truth.

In our every day lives, we avoid this epic confrontation by appealing to the jurisdiction of one theory at a time. This works rather well, because most of the objects and phenomena we probe are either very small (the province of quantum mechanics) or very heavy (the province of general relativity). But occasionally, the two domains overlap - in objects like black holes, or situations such as those that presided in the early universe - and we need to deal with things that are extremely tiny, yet very dense; in these disputed regions, an ideological battle is unavoidable.

This conflict could, everywhere and forever, be put to rest if we were to somehow discover a single theory that applies across the physical universe; a theory that modifies, or extends, the existing schemes - a larger, more expansive structure, that subsumes both quantum mechanics and general relativity; this ‘unified' theory is the holy grail of physics. (I would be remiss if I did not point out that string theory - which gets a lot of bad press due to its current lack of testable predictions - is, at least so far, the most promising contender we have for this elusive theory of everything.)

As in the quests of old, our path is strewn with obstacles. We know the two warring theories cannot be completely correct, but they have both, thus far, resisted every attempt we have made to put them in the wrong. Quantum mechanics and general relativity have been extensively checked, but haven't yet been able to poke holes in the structure of either theory.

And that brings me - finally - to the point I started out to make: gravitational waves were one of the more exotic predictions of general relativity. The chirp heard by LIGO ratifies our faith in Einstein's theory, but a signal this faint would have been impossible to detect, had we not fully exploited our knowledge of the quantum world. In this much vaunted triumph of general relativity, quantum mechanics has played a crucial role yet it stands silently in the wings, content to let the glory of the moment go to its supposed rival.

The gesture is a generous one, even noble. It makes me wonder if perhaps this narrative of a ‘fight to the death' is something we have imposed on these two theories; maybe a theory of quantum gravity will not emerge victorious from the battlefield, but instead be forged in quiet moments of cooperation such as this.

Maybe tapping into that synergy is the only real way out of every drama we dream up, every conflict we lose sleep over.

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