Tales behind the tags

Physics is crowded with evocative phrases, but these alone cannot show the whole picture.

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"What is it that human beings ultimately depend upon? We depend on our words. We are suspended in language. Our task is to communicate … without losing the objective or unambiguous character [of what we say]." Thus spoke Niels Bohr, the most linguistic of oracles in twentieth-century physics. Yet the charm of memorable speech can and does mislead us all.

Take the tag 'relativity'. It bears the memory of Einstein as a kind of catchword. But it was equally the work of that gifted First Physicist, Galileo Galilei, expressed in 1632 in a book of vivid conversation. His central character, Sagredo, recalls the first hours of a voyage out of Venice one calm and tranquil day. Once afloat, he wrote in his journal. Attentive Simplicio puts it well: "The gross motion from Venice … was common to the paper, the pen, and everything else in the ship. But the small motions communicated to the pen by the fingers, but not to the paper, could leave a trace." The two lines traversed by pen and paper as they were carried along on the ship were miles long, yet never so much as a foot apart. They thus differ subtly; it is the complex shifting distance between them that builds the record. Only relative motion counts locally, whenever the common motion is sufficiently uniform in its speed and direction. We all move as the Earth moves; we can view 'gross motion' in the sky or from it, but we do not feel it.

That was the first relativity. It was named 'galilean relativity', only after that famous paper was detonated in 1905 by a young Albert Einstein. By then, it was no longer planetary motion but electromagnetism that held puzzles. Only the relative motion between a magnet and a coil of wire matters to the dynamo; all agreed on this, including Einstein. Only the speed of light in space is not relative as other speeds are; it does not depend on whether the source of light or the detector moves, but only on their relative motion. By seeking the winds of the ether, physicists should have revealed the 'gross motion' of the Universe, but they certainly did not. No apt experiment, using any sensitive optical or electrical measurements, showed the ether drifting by.

Einstein explained this in six meticulous pages, using minor algebra. He boldly did away with the ether in his assumptions, and instead fixed for all observers the well-known absolute speed of light in empty space. All

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other speeds were relative, reckoned by a new calculation. This had extensive implications for measurements of time and motion — fundamental intervals, such as the duration of a watch tick, and space intervals, depend on the speed of the experimenter relative to the instruments he sets up. The closer a simple motion comes to light's huge limiting speed, the more galilean relativity gives way. But relative motion is the basis of Galileo's space in three dimensions, just as it is for Einstein's space-time in four. Yet 'relativity' remains a tag that is associated with Einstein.

A more recent tag — which appears everywhere in vernacular cosmology, from comic strips to scientific papers — is the 'Big Bang'. Our cosmology is rickety compared with the stringently tested 1905 'special relativity' of Einstein. His 'general relativity', which describes curved space–time and incorporates gravitation, still frames our cosmology, the foundations of which are only two or three decades old. It ought to surprise us that the primal grand event, which is claimed to be the origin of all that there is, including space–time itself, has such a flippant name. The term was coined during a 1950 series on BBC radio by Fred Hoyle, a brilliant, fruitfully iconoclastic astrophysicist, whose firm intent then was to put down the naivety of the simple idea. (Sir Fred, aged 86, passed away in August this year.)

The Big Bang was based on a smooth extrapolation to the limit of cosmological equations (first written by Einstein in 1918 and significantly elaborated upon). In the simplest model, the Universe began at an implicit infinite limit, in which space was completely filled by very different matter from that which today makes up the Universe. Nowadays, the data from the sky favour a much more complex narrative featuring early staccato changes, called inflation, which have interrupted and indeed gave rise to the present long-standing expansion. The term Big Bang remains, confusingly, still in use for the wider observable

Seafaring story: a voyage from Venice was the setting for Galileo's description of relativity.

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features that followed from a very much stranger and incompletely known past. We do not know what the beginning was like — or even if there was a beginning.

Bohr argued that physics concerns not what nature is, but rather what we can clearly say (and not say) about it. Science owes the outside world a clear, brief account of its views, but these accounts will never be clear until we go beyond mere buzz-words and start conveying real ideas, as Sagredo did. Perhaps we can enlist verbs to illuminate the nouns. Poetic, even ironic, tags catch on well, but name tags are just not enough. ■

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FURTHER READING

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