Constants Are Just Not the Same Anymore: the Odd Australian Dipole

By Mark Martinez

One of the fundamental properties of physical laws is space-time invariance. Physics, classical to modern, from Newtonian mechanics to Einstein's fundamental formulations, relies on the coherence of all such theories - including the constants employed within these frameworks. So what would happen if all these constants were not necessarily constant? From a macroscopic, geocentric standpoint, a constant having a variable value in a far off part of the universe seems quite irrelevant to everyday life. However, if fundamental constants were found to be variable over space and time, then a very urgent theoretical remodeling would be necessary. To explain the impact of even a miniscule change in a constant's definition, simply consider the specificity of Earthly parameters which life depends upon: a difference of 1 °C would cause major changes in the world's ecosystems - melting polar ice caps, raising water levels, making fish easier to catch - and thus disrupting the population dynamics of polar bears and all their interaction partners, to give one example. Imagine a change in something invisible to the human eye, such as an atom. A change in atomic radius would change bond lengths and reconfigure molecular structures, conferring different properties to all of matter: mountains, oceans, organisms, hormones within humans, technology…! A recent paper released by John Webb, an Australian physicist at New South Wales University (5), presents the possibility that one of the fundamental constants of the universe is actually a misnomer. Webb conducted the research by observing over 300 different quasars using two of the world's largest telescopes, the Keck telescope in Hawaii and the Very Large Telescope (VLT) in Chile (1,5). Beginning work in 1998, the researchers in the northern hemisphere observed over 150 different galaxies before coming to a consensus about α — the fine structure unitless constant describing how electrons affect binding between atoms and molecules. However, after repeating the study in the southern hemisphere, Webb calculated a different α value - the difference which is now dubbed the "Australian dipole" (3). Because the Keck and VLT are in different hemispheres, they are able to view different parts of the universe and it was in these distinct regions of the universe that the fine structure constant seemed to vary. Although both sets of quasars represent a time near the beginning of the universe (as they both are several giga-lightyears away), their differing spatial identities seem to modulate the value of α. The two α values differ by a factor of 1/100,000. The fact that a constant could actually be a variable of time and space has caused a rift between physicists (4) and the consequences of the new findings are far-reaching (3). Einstein's equivalence principle, one of the fundamental principles of relativity, states that, in every part of the universe, all constants must always remain invariant. And so, for many, the lack of experimental equivalence is a boulder blocking those seeking a unified theory - an attempt by modern physicists to combine the four fundamental forces, gravity, electromagnetism, and both strong and weak nuclear forces. The emergence of inconsistent constants has complicated the pursuit of a unified theory as some physicists believe that traditional invariance is due to existence of extra dimensions. H

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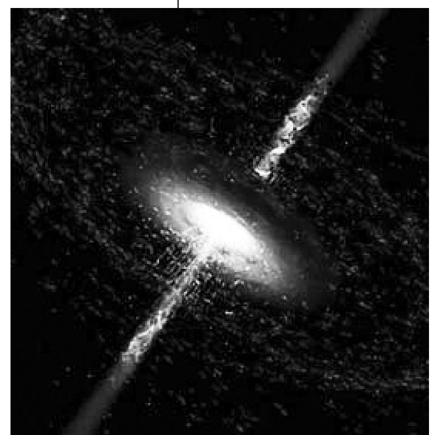

▲ **Figure 1.** A jet emanating from Quasar 3C 273.

credit: http://rst.gsfc.nasa.gov Image taken by Nicholas Short.

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3. Hamish Johnston; Changes spotted in fundamental constant
4. John Webb; Laws of physics vary throughout universe, study finds http://www.science.unsw.edu.au/news/laws-of-physics-vary/
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