The First Turbulent Mixing and Combustion

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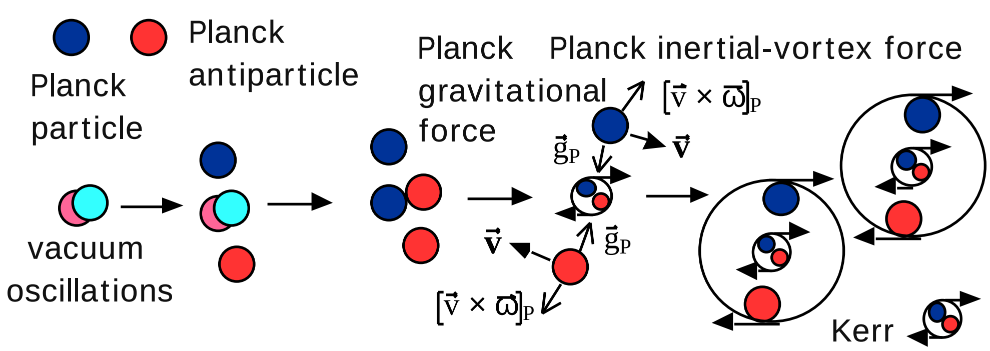
Abstract

The first turbulence, turbulent mixing, and turbulent combustion initiated the hot big bang universe in the epoch of quantum gravitational dynamics. Heisenberg's uncertainty principle allows a small probability for otherwise reversible vacuum oscillations at Planck scales to irreversibly produce Planck particles and antiparticles at the Planck mass for times longer than the Planck time. These smallest possible Schwarzschild (nonspinning) black holes can then produce the smallest possible mass Kerr (spinning) black holes instead of annihilation. Planck turbulent inertial vortex forces between the Kerr particles and Planck particles match Planck gravitational forces to inhibit quenching and propagate this powerful spontaneous explosion of space-time-energy at Planck temperatures by a cooling cascade of turbulent mixing to larger scales, triggering further pair production and the big bang itself. Planck viscous forces are smaller than the turbulent inertial vortex forces, with Reynolds numbers increasing to 10^6. Entropy increases during big bang turbulence are by thermal and viscous dissipation of temperature and velocity variance χ and ε, so by dimensional analysis the temperature power spectrum should be the Corrsin-Obukhov form $\varphi_T = \beta\chi\varepsilon^{-1/3}k^{-5/3}$, where β is a universal constant of order one and k is wavenumber. Strong forces freeze out at temperature 10^{28} K to produce quarks and gluons, but a false vacuum supercooling causes a brief exponential stretching of space by a factor of 10^{25} according to the Einstein theory of general relativity and the Guth theory of inflation. The temperature spectrum is stretched to scales larger than the horizon scale of causal connection ct, where c is the speed of light and t is the time, so that the expanded pattern of turbulent temperature fluctuations is the first fossil temperature turbulence. The fluctuations reenter the horizon at 10^{-9} s before nucleosynthesis and imprint the fossil turbulence pattern on the resulting density and species concentration fields because of the extreme temperature sensitivity of these reactions. Velocity deviations from the expanding Hubble flow are damped by viscous forces transmitted by photons and neutrinos, but density and species concentration fields are less diffusive and persist through the radiation dominated and matter dominated

plasma epochs to be visible on the sky as cosmic microwave background temperature fluctuations δT, red shifted a factor of 1100 from the white hot temperatures of the plasma-gas transition. Superposed on the observed fossil big bang turbulence spectrum is a peak at 1/10 the CMB horizon length scale, indicating the time of first gravitational structure formation was about 10^{12} s. This is the time when the horizon mass $\rho c^3 t^3$ matched the mass of the largest structures of the universe (10^{46} kg for superclusters of galaxies), where ρ is the average density of a flat universe from Einstein's equations, and is also the time when the viscous Schwarz scale $(\nu\gamma/\rho G)^{1/2}$ matched the horizon scale ct, where ν is the photon viscosity, γ is the Hubble rate of strain 1/t, and G is Newton's gravitational constant. An alternative interpretation of the CMB spectral peak as sonic oscillations of the primordial plasma is ruled out by the large viscous damping and lack of any primordial sound sources powerful enough to produce the observed CMB $\delta T/T$ levels of 10^{-5}. Gravitational structure formation in the plasma contradicts the Jeans 1902 linear acoustic criterion because the Jeans length scale $V_S/(\rho G)^{1/2}$ is larger than the horizon ct, where V_S is the speed of sound. The Jeans scale criterion is unreliable according to Schwarz scale criteria proposed by Gibson 1996-2001. The Gibson theory predicts viscous and weak turbulence forces dominate gravitational condensation after the plasma to gas transition at a trillionth of the Jeans mass to produce primordial fog particles with small-planetary-mass. These comprise the interstellar dark matter of galaxies, 3×10^7 frozen rogue planets per luminous star, as observed by Schild 1996 from the twinkling frequency of quasar images lensed by a galaxy, and by Hubble space telescope observations of thousands of planet mass cometary globules surrounding the hot dying stars of planetary nebula. Frozen hydrogen and helium of the planets are evaporated to produce large, visible, atmospheric cocoons and vapor trails.



Big Bang turbulence, mixing, and combustion