Vertical stratified turbulent transport mechanism indicated by remote sensing

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Satellite and shipboard data reveal the intermittent vertical information transport mechanism of turbulence and internal waves that mixes the ocean, atmosphere, planets and stars.

Astronauts noticed they could see deep bottom features and internal waves within the ocean from space platforms (Figure 1), but were not believed because no known physical mechanism permits remote sensing through kilometers of opaque water. The information transport mechanism is generic to all large stratified intermittently turbulent bodies of natural fluid. Vertical (radial) heat, mass, momentum and energy transport are affected. The mechanism involves turbulence, fossil turbulence and nonlinear internal waves. A three year series of oceanographic experiments were organized to test Russian claims they could detect submerged turbulence, internal waves, bottom depth and topography from space satellites.

1 Turbulence is defined as an eddy-like state of fluid motion where the inertial-vortex forces \( \mathbf{v} \times \mathbf{\omega} \) of the eddies are larger than any other forces that tend to damp the eddies out, where \( \mathbf{v} \) is the velocity and \( \mathbf{\omega} \) is the vorticity. Thus, turbulence always cascades from small scales to large.

2 Fossil turbulence is defined as a perturbation in any hydrophysical field produced by turbulence that persists after the fluid ceases to be turbulent at the scale of the perturbation.

3 When active turbulence cascades to the (Ozmidov scale) maximum vertical size permitted by buoyancy \( L_s = \left( \frac{e}{N^2} \right)^{1/3} \), it fossilizes, and the turbulent kinetic energy is radiated near vertically as fossil and zombie turbulence waves.

4 Zombie turbulence is produced when density gradients of fossil turbulence patches are tilted by internal waves to create vorticity at rates \( (\nabla \rho \times \nabla \rho) / \rho \).
Figure 2 shows RASP data and how it was obtained and analyzed. Brightness anomaly wavelengths suggest Ozmidov scales at fossilization from strong turbulence events radiate narrow spatial-frequency packets of fossil turbulence waves near-vertically. Detected wavelengths (40-160 meters) are confirmed by thermistor-chain internal-wave measurements and surface-wave detectors. Horizontally towed and vertically dropped microstructure profilers contoured viscous and temperature dissipation rates and tested for hydrodynamic states of the patches. Intermittent mixing chimneys were detected.

The mechanism for vertical transport is termed “Beamed Zombie Turbulence Maser Action” (BZTMA), and occurs in intermittent mixing chimneys. The outfall fossil turbulence patches drift away from their source with ambient currents, and absorb energy from bottom generated fossil turbulence waves to form zombie turbulence and zombie turbulence waves in an efficient maser action that moves length-scale-information for the bottom waves to the sea surface where the zombie-turbulence-waves (ZTWS) break and permit its detection. Vertical ZTW chimneys follow paths of previous ZTWs, just as lightning flashes follow ionized paths of previous lightning flashes. The BZTMA mechanism is an extension of Kolmogorovian universal similarity theory with extensions to scalar mixing. Consequently it is generic to natural fluids such as the ocean, atmosphere, planets and stars.

**Astrophysical implications**

Application of modern fluid mechanics to astrophysics reveals the dark matter of galaxies as thirty million Primordial-Fog-Particle earth-mass frozen-gas planets (PFPs) per star in Proto-Globular-star-Cluster-mass clumps (PGCs), but requires the use of BZTMA to explain why stars form and die in different ways and why it is not necessary to believe in dark energy. Figure 3 shows 12 decades of Kolmogorov-Corrsin-Obukhov electron density spectra from earth scales to PGC scales that require planetary atmospheres evaporated by nearby supernovae (II) and their resulting pulsars. This requires strong BZTMA mixing by planet accretion. Otherwise the carbon cores of stars will not be mixed away, giving supernovae Ia.

**Conclusions**

Stratified turbulent mixing in natural fluids is dominated by the most powerful turbulent events of a vertical column, which fossilize and radiate nonlinear internal waves near-vertically. These mix to form fossil turbulence patches, secondary zombie turbulence events, mixing chimneys and information transport to the surface by the BZTMA mechanism. This explains why deeply submerged seamounts and internal waves (Fig. 1) can be seen and why vast undersampling errors are typical in physical oceanography when fossil turbulence and fossil turbulence waves are neglected.
Figure 3. Application of BZTMA mixing theory to understand pulsar electron density fluctuation spectra and star formation from planets. Jovian PFP (primordial–fog-particle) Planets (JPPs) comprise the baryonic dark matter of all galaxies and develop turbulent atmospheres when evaporated by radiation from rapidly spinning white dwarf and neutron stars.

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