Submerged waves seen from space through their transport mechanism

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Satellite and shipboard data reveal the intermittent vertical information of the transport mechanism from turbulence and internal waves, which emit within the ocean, the atmosphere, and by planets and stars.

Astronauts noticed they could see deep bottom features and internal waves from space platforms (see Figure 1), but were not, at first, believed because no known physical mechanism permits remote sensing through kilometers of opaque water. To test Russian claims that they could detect submerged turbulence, internal waves, bottom depth, and topography from space satellites, a three year series of experiments were organized: the Remote Anthropogenic Sensing Program (RASP 2002, 2003, 2004).

The results suggest that stratified turbulence transports information near-vertically through the ocean. Furthermore, the transport mechanism is generic to all large stratified intermittently-turbulent bodies of natural fluid. Therefore, this work applies to astrophysics as well as oceanography.

Vertical (radial), heat, mass, momentum, and energy transport are affected by the transport mechanism, which involves turbulence, fossil turbulence, and nonlinear internal waves. To define our terms: turbulence is an eddy-like state of fluid motion where the inertial-vortex forces of the eddies are larger than any other forces that tend to damp the eddies out. (Turbulence always cascades from small scales to large.) 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. Nonlinear internal waves occur when active turbulence cascades to the maximum vertical size permitted by buoyancy and fossilizes: the turbulent kinetic energy is radiated near-vertically as fossil turbulence waves (FTW) and zombie turbulence waves (ZTW). Zombie turbulence occurs when internal waves tilt density gradients of fossil turbulence patches.

The RASP experiments used the turbulent Honolulu wastewater outfall at Sand Island. Detailed sea truthing was made during space satellite observations. Buoyancy traps wastewater at a depth of 50m to prevent contamination of surface waters and beaches. Remarkably, outfall fossil and zombie turbulence patches can dominate mixing in Mamala Bay at distances exceeding 20km in areas exceeding 200km².

The mechanism

Figure 2 shows RASP data. Brightness anomaly wavelengths, from light spectra, suggest that Ozmidov scales at fossilization from strong turbulence events radiate narrow-spatial-frequency (λ) packets of FTWs nearly vertically. The lengths of the brightness waves (40–160m) were reproduced by sea-truthing thermistor-chain internal-wave measurements and surface wave detectors. Horizontally-towed and vertically-dropped microstructure profilers contoured viscous and temperature dissipation rates and determined hydrodynamic states of the

Continued on next page
Figure 2. Sea surface brightness anomalies are detected by comparing 2D-spectra near the outfall (red) with background regions (green). Corresponding internal wavelengths (right) suggest fossil turbulence waves radiated from the bottom.

patches. (Paths of some on-the-water data collectors are shown in Figure 3.) Intermittent mixing chimneys were detected.

The mechanism for vertical transport is termed ‘beamed zombie turbulence maser action’ (BZTMA). Outfall fossil turbulence patches drift with ambient currents and absorb energy from bottom-generated FTWs to form zombie turbulence and ZTWs in an efficient maser action. ZTWs move λ-information from the bottom FTWs to the sea surface where the ZTWs break and permit its detection. In the seas, vertical ZTW chimneys follow paths of previous ZTWs, much like lightning flashes follow ionized paths of previous lightning flashes in the atmosphere.

**Astrophysical implications**

The BZTMA mechanism follows the rules of Kolmogorovian universal similarity theory with extensions to scalar mixing. Consequently, it is generic to natural fluids such as those found within the ocean, the atmosphere, and within planets and stars. The application of modern fluid mechanics to astrophysics, for example, 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, BZTMA theory is required to explain why stars form and die in different ways and why the existence dark energy may not be true. Figure 4 shows 12 decades of Kolmogorov-Corrsin-Obukhov electron density spectra from earth-scales to PGC-scales that imply dense planetary atmospheres evaporated by
Type II supernova events and their resulting pulsars. Precursor SNe-II (iron core) stars suggest strong BZTMA mixing by rapid PFP accretion. If this were not possible, the carbon cores of stars would have not mixed away, and the Type Ia supernova events would not have occurred.

Conclusions
Stratified turbulent mixing in natural fluids is dominated by the turbulent events in a vertical column. These events fossilize and radiate nonlinear internal waves near-vertically. The fossil turbulence waves and patches produce secondary zombie turbulence events, mixing chimneys, and information transport to the surface by the BZTMA mechanism. This phenomena explains why deeply submerged seamounts and internal waves (see Figure 1) can be seen, while also explaining the vast undersampling errors (see Figure 2) typical in physical oceanography that occur when fossil turbulence and fossil turbulence waves are neglected.

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Figure 4. Application of BZTMA mixing theory to understand pulsar electron density fluctuation spectra and star formation from planets. Jovian primordial-fog particle (PFP) planets comprise the baryonic dark matter of all galaxies. JPPs also develop turbulent atmospheres when evaporated by radiation from rapidly spinning white dwarf and neutron stars.
References