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Editorial: Plasma waves in space physics: Carrying on the research legacies of Peter Gary and Richard Thorne

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Editorial on the Research Topic
Plasma waves in space physics: Carrying on the research legacies of Peter Gary and Richard Thorne

The importance of plasma waves to the evolution of the solar wind and to the evolutions and interactions of the multiple particle populations of the Earth's magnetosphere is overwhelming. Two giants in the field of plasma-wave physics recently passed -- Peter Gary and Richard Thorne (cf. Figure 1). Peter and Richard largely established the complexities of plasma waves, plasma instabilities, wave-particle interactions, and the dissipation of turbulence. They opened the eyes of the space-research community to the impact of plasma waves in the solar wind and in the Earth's magnetosphere. Seminal publications are (Thorne et al., 1973; Thorne, 2010; Thorne et al., 2013; Gary et al., 1984; Gary 1991; Gary and Smith, 2009) and the textbook Gary (1993). They both collaborated widely both nationally and internationally, a key factor that made them world leaders. The Frontiers Research Topic "*Plasma Waves in Space Physics: Carrying On the Research Legacies of Peter Gary and Richard Thorne*" was designed to honor their hard work, their accomplishments, and their leadership and to extend their research legacies into the future.

The goals of the Research Topic were 1) to celebrate the scientific achievements of Richard Thorne, Peter Gary, and the entire space-plasma-physics research community, 2) to showcase state-of-the-art research findings, and 3) to take an assessment (a) of the present state of knowledge and (b) of where the research community goes in the future.

From this Frontiers Research Topic 14 papers on plasma waves, wave-particle interactions, plasma-wave instabilities, and plasma turbulence are contained in this electronic book. Synopses of the 14 papers are as follows, ordered by papers that focus on 1) plasma waves, 2) wave-particle interactions, 3) plasma-wave instabilities, and 4) plasma turbulence.

Hartinger et al. (2022) review the progress made by the "ULF Wave Modeling, Effects, and Applications" GEM focus group. This review article makes the connection of modern UL F wave research to the ULF wave research of Peter Gary and Richard Thorne.

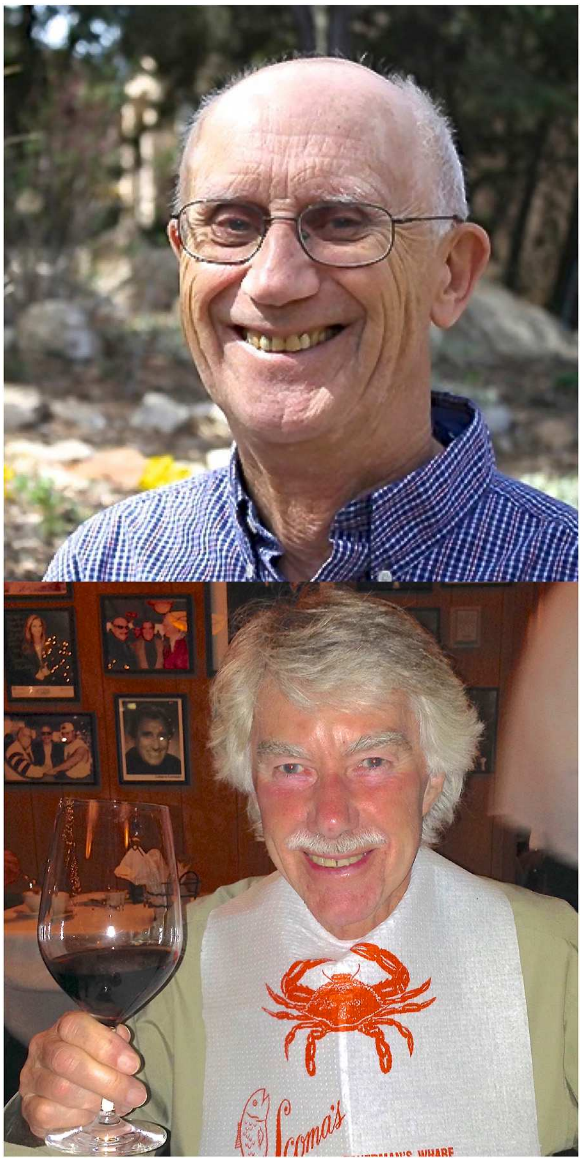

FIGURE 1
Photographs of Peter Gary (top) and Richard Thorne (bottom).

Albert et al. (2022) examine the equations of motion for test particles encountering field-aligned whistler-mode waves. The investigation focuses on which approximations in the equations of motion capture phase trapping and phase bunching as functions of particle pitch angle.

Haas et al. (2022) examine the pitch-angle distribution of ~10 keV electrons in the ring-current region of the Earth's magnetosphere finding that wave-particle interactions are a minor contributor for moderate storms but an important contributor for strong (Kp > 6) storms. They investigate the use of the Kp index as a proxy (predictor) of the flux of electrons in the ring current region of the Earth's magnetosphere.

Lejosne et al. (2022) review different physical processes that lead to the energization of radiation-belt electrons. They specifically compare radial-diffusion acceleration versus chorus-wave energization, pointing out the insightful contributions of Richard Thorne in focusing on whistler-mode-chorus wave-particle interactions. The Lejosne et al. review highlights the existing challenges in discerning the relative importance of the two processes (radial diffusion versus whistler-mode wave-particle energization) for radiation-belt electron acceleration.

Smirnov et al. (2002) extensively examine the evolution of outer-radiation-belt electron pitch-angle distributions during 129 geomagnetic storms, versus the energy range of the electrons and verses dayside/nightside. They find that the pitch-angle distributions of lower-energy electrons show little evolution through a storm but that higher-energy electrons show distinct evolution through the various phases of a storm.

Borovsky (2021) discusses a system-science view of diverse ion and electron populations interacting *via* wave-particle interactions, both in the solar wind and in the Earth's magnetosphere. An important point is that the diverse ions and electrons are co-located because of their confinement by the magnetic field.

Verscharen et al. (2022) review multiple electron plasma-wave instabilities in the solar wind driven by non-equilibrium electron distributions as a function of distance from the sun. The review importantly discusses unsolved questions about electron-driven instabilities in the solar wind.

Zenteno-Quinteros and Moya (2022) examine the whistler-heat-flux instability in the solar wind driven by the high-energy tails of the solar-wind electron distribution functions. They use a "core-strahlo" description of the electron distribution with a skewed kappa distribution of the strahl population.

Winske and Wilson (2002) focus on Peter Gary's contributions to the understanding of electromagnetic ion-beam instabilities driving ULF waves in the Earths foreshock. The discussion focuses on theory, ISEE-spacecraft observations, and subsequent unsolved Research Topic.

Le et al. (2003) examine the resonant right-hand ion-beam instability in the Earth's foreshock driven in the solar-wind plasma by ions reflected from the Earth's bow shock. Using hybrid computer simulations and spacecraft observations they find that plasma-wave modes with a variety of propagation angles are excited.

Birn et al. (2022) examine the statistics of test electrons in MHD simulations of magnetotail dipolarization events to examine expected electron anisotropy distributions which could drive plasma waves *via* micro-instabilities. They confirm that the dynamics of the electrons are chiefly governed by betatron and first-order Fermi acceleration.

Narita et al. (2002) overview the legacy of Peter Gary, who made large contributions to the picture of short-wavelength plasma turbulence. In the kinetic range of turbulence two pathways for energy cascade are discussed, one involving Alfven waves and the other involving magnetosonic waves.

Cui et al. (2022) use particle-in-cell simulations to explore the various roles that the whistler-anisotropy instability play in whistler turbulence. They find that the whistler-anisotropy instability may act as a regulation mechanism for turbulence in the kinetic range *via* wave-particle interactions.

Allanson et al. (2022) use a Markovian approach to examine charged-particle dynamics for electromagnetic waves propagating parallel to or antiparallel to a uniform magnetic field. They derive quasilinear diffusion coefficients are derived using this physically intuitive approach.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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