Waves & Oscillations in the Solar Atmosphere:
Heating and Magneto-Seismology
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Concluding remarks

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Waves in solar and stellar atmospheres have been proposed more than fifty years ago to heat the chromosphere and the corona. Their usefulness as a means to explain an important phenomenon gave wave science its initial impetus. However, since then, waves and oscillations have become a great astrophysical topic of their own. In an inhomogeneous medium, waves occur in immense variety. The theory of waves explores this complexity and highlights modes and properties that are important in stellar atmospheres. We have seen steady progress in this fundamental endeavour that has recently been accelerated through the use of numerical simulations. The discovery, three decades ago, of waves in the solar and stellar interiors and later in the corona, although at low energy levels, opened a new field: the diagnostic use of waves. Seismology of the interior has become a booming field of solar and stellar physics, and observed oscillations have been used to derive the magnetic field strength and to explore the corona.

In the competing process for coronal heating, magnetic reconnection, waves have also been realised to have an important function: reconnection launches two jets of outflowing plasma that can be comprehended as large amplitude Alfvén waves. More importantly: flares are well known as accelerators of energetic electrons and ions. More than half of the flare energy is first observed in non-thermal particles. The currently most popular theory interprets flare particle acceleration as stochastic resonance interaction of particles with waves (transit-time damping). The damped waves are suggested to have cascaded from originally long-wavelength waves produced by reconnection. Thus flares (and possibly nanoflares) may be considered as prolific wave generators.

Waves and oscillations may not be just fringe phenomena. A misleading picture may be given by the Earth's atmosphere, where waves play a minor role because the energy of a major disturbance, such as a body moving through the air, dissipates energy by driving vortices. In a magnetized plasma, the role of vortices in a neutral gas is taken up by waves. Situations where waves reach a significant energy density and substantially influence the dynamics may thus be more frequent.

The IAU Symposium 247 has followed waves and oscillations from the tachocline in the solar interior to shock waves produced by coronal mass ejections into interplanetary space, also including stellar applications. The observable phenomena are very different, but waves have emerged to be a unifying theme that connects many different phenomena and concepts.