Kenneth George Budden is awarded the Royal Astronomical Society’s Gold Medal for his lifelong research into the propagation of radio waves in the ionosphere and magnetosphere, in particular, for his theory on the conversion of energy between different wave modes in a non-uniform magnetized plasma, and for his inspired teaching of generations of students.

During the Second World War, Dr Budden was involved in the development of radar. He continued his research at the University of Cambridge into the reflection of radio waves from the ionosphere and developed full wave techniques to describe wave reflection and tunnelling where scale lengths in the medium may be comparable to the probing wavelength. The general equations governing the propagation of radio waves were intractable at the time and thus he was quick to exploit the first Cambridge University computer, EDSAC, as a tool to solve real physical problems.

This work had, and still has, practical applications. Radio propagation studies in the ionosphere are important for broadcasting and for radio communications around the world at HF frequencies below the ionosphere. Even today, with the advent of satellite communications at much higher frequencies, a knowledge of the effects of the ionosphere on HF radio propagation is important when one considers that satellite communications may not always be possible during a period of conflict if one does not own the satellite. In 1966 Dr Budden was made an FRS for his outstanding contribution on radio propagation in the ionosphere.

Dr Budden’s outstanding contribution centres on the conversion of energy from one wave mode to another in an anisotropic magnetized plasma. He used both ray theory, which is subject to the assumptions of geometric optics, and full wave theory to expound his ideas.

He showed that electromagnetic radiation, which can propagate through a plasma provided the frequency is above the plasma frequency, can be converted into another type of radiation, which is confined locally to the plasma, at two so-called radio windows. These windows are regions where the refractive index of the incident and locally confined radiation are approximately equal. Dr Budden developed equations to describe the efficiency of energy conversion for a range of propagation angles and showed that the highest efficiency occurs for propagation along the magnetic field when the wave frequency equals the plasma frequency. The test of a good theory is that it can be applied successfully in many areas. This is certainly the case for Dr Budden’s theories. For example, ionospheric sounders are used to probe the different layers of the ionosphere and usually only receive two reflections corresponding to the ordinary (O) and extraordinary (X) modes. However, a third reflection is sometimes found and has been explained using Budden’s theory in terms of a coupling to and reflection from a local plasma mode, the Z mode. In fact, using Dr Budden’s theory it was shown that when the third reflection occurs it is possible to identify the critical ionospheric plasma frequency very accurately. This is of the utmost importance for propagation studies.

Dr Budden’s work on resonance tunnelling has been applied to the Earth’s magnetosphere to explain the excitation of standing hydro-magnetic waves. These are oscillations in the Earth’s magnetic field at ULF frequencies which are recorded on the ground using magnetometers. His ideas have also been applied to laboratory and fusion plasmas. In these applications the main object is to deposit wave energy into the plasma to help raise the temperature for thermonuclear ignition. Dr Budden’s theory has been used to determine the most efficient way of coupling radiation generated outside the device to plasma waves inside the device which subsequently heat the plasma, and to minimize reflection of the incident radiation at the surface of the plasma.

His fundamental work on mode conversion at radio windows has been used to explain some of the strongest radio signals emitted from the Earth, known as auroral kilometric radiation, and radio emissions from Jupiter, Saturn and Uranus. In these applications the waves are generated locally in the plasma by wave-particle interactions and then converted into free space O and X mode radiation which escapes from the planet. His mode conversion theory at the so-called second radio window has also been used to explain VLF radiation generated in the Earth’s magnetosphere which is detected on the ground at high latitudes as auroral hiss.

During his career Dr Budden has published four books, one of which, Radio Waves in the Ionosphere, has become a classic. Although much of his work has been highly mathematical, he has always had the gift to explain the physical significance behind the equations to students and researchers alike. He truly understands physics. This has inspired many of us who have had the pleasure of learning from him to teach others in a similar way.

Richard B Horne, BAS Cambridge.

Dr Kenneth George Budden FRS
Address given by the former President of the RAS, Prof. Malcolm Longair, on the presentation of the Gold Medal of the Royal Astronomical Society to Dr Kenneth George Budden FRS.

Agnes Clerke commemorated
Mary Brick reports on a fitting memorial in County Cork.

A plaque commemorating Agnes Mary Clerk (1842–1907), the historian of astronomy, and her sister Ellen Mary (1846–1906), poet, writer, and nurse, was unveiled at their birthplace in Skibbereen, County Cork, on 11 July 1999.

The sisters grew to adulthood in Skibbereen and later lived in Dublin and Italy before settling in London in 1877.

Agnes Clerke is chiefly remembered as the author of A Popular History of Astronomy during the Nineteenth Century (1885 and later editions), which is still an indispensable source of information on that period.

Ellen Clerke’s preferred field was Italian literature, but as a professional journalist she wrote with authority on a wide range of subjects including astronomy.

The Clerkes were members of the British Astronomical Association and faithful attendants at meetings of the Royal Astronomical Society from 1892 onwards, when women with a serious interest in astronomy were welcomed as guests. Agnes Clerke was one of the few women to be elected (in 1893) as an honorary member of the Society.

It is fitting that the sisters should be jointly commemorated: we are told that they were “lovely and pleasant in their lives, and in death they were but little divided” (Lady Margaret Huggins, privately printed Appreciation 1907).