Editorial

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This issue celebrates what is now known as the 'physics of condensed matter', The back cover personality, Walter Kohn, is a legend among theoretical physicists. The general article, the Classics piece extracted from his path breaking paper, and the biographical sketch leave little more to be said here. In summary, a paper was written with the modest title 'Inhomogenous Electron Gas' in 1964, proving an apparently academic theorem that a certain function of electron density exists whose minimum gives the true ground state energy. This led to a revolution in computing the properties of materials in our times, recognized by the 1998 Nobel Prize for Chemistry.

It is interesting to see the rise of condensed matter physics in perspective. By the middle of the 20th century, the physics of perfect crystalline solids, based on the quantum behaviour of electrons, was beginning to take its present form. It needed a lot of insight at that time to see that the physics of materials poses theoretical questions as rich and deep as any in the realm of elementary particles. An even deeper insight came later – problems in these two realms have more in common than one might think at first. Our February issue told the story of Ken Wilson, one of the pioneers in seeing this deep connection, in a very specific area – continuous phase transitions.

Condensed matter physics expanded to embrace new phenomena which were rapidly being uncovered by experimenters in systems of great interest in biology and technology. The list includes membranes, polymers, liquid crystals, colloids, powders, and other systems which are condensed – not gases – but not simple liquids or solids either. Their rich range of behavior is governed by classical physics, goes by the broad name of 'soft condensed matter' but poses hard problems which continue to challenge the best physicists to this day.

From the 1960s, the strange behavior which electrons exhibit when they interact strongly with each other, has been a major theme of condensed matter physics – see the December 2005 issue of *Resonance*. The new ingredient in the more recent, developments is topology. By the 19th century, mathematicians knew of certain geometrical properties which are independent of any notions of length, angle or size. These properties are robust – they are preserved even if one distorts the object continuously. As a deceptively simple example, a closed curve drawn on the plane has an inside and an outside. If one goes from inside to outside one crosses the boundary an odd number of times. These statements remain true however much one distorts the curve (continuously!) – hence the name 'rubbersheet geometry'. The late 19th and early 20th centuries saw the foundations laid for a vast and deep generalization of these isolated ideas. Today, most mathematics degrees include a course in topology, which may not use many figures. A simple search of the *Resonance* archives throws up a large number of articles on this subject. The word itself is a translation of Poincaré's Latin phrase *analysis situs* – the 'situs' stands for location or position.

It is interesting that high energy physicists and in particular string theorists were always required to learn some topology as part of their training – and likewise those working on ordered media like liquid crystals. The application to electrons, winning the 2016 Nobel Prize, is rather different – the seeds were sown in the early 1970s and 1980s, but applications and understanding are very much a work in progress. The more technical article in this issue, on emerging trends in topological insulators and semiconductors gives a flavor of this current excitement. For a field founded on apparently esoteric mathematics, the level of experimental activity is impressive. The fundamental reason is that a topological property is robust against distortions. The physics of condensed matter has once again surprised and enlightened both practitioners and onlookers. It promises new applications and devices under 'topological protection' which could not have been anticipated even a decade ago.