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Index theorem, skyrmions and the Witten effect in topological quantum systems

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Topological materials have attracted much attention from both physicists and mathematicians recently. Topological properties are closely related to the index theorem. The index theorem known as the Atiyah-Singer index theorem is formulated on a manifold without boundary. An interesting phenomenon will appear when considering the index theorem for manifolds with boundaries. We discuss such interesting phenomena in topological systems including a topological superconductor that emerge from the boundary effect. The boundary effect will result in fractional quantization of charges (that is, the existence of magnetic and electric charges). The Witten effect will also be very attractive when the Dirac electron exists, for example, on the surface of topological materials.

Keywords: topological materials, index theorem, monopoles, Witten effect