Roger Penrose

# THE ROAD TO REALITY

A Complete Guide to the Laws of the Universe

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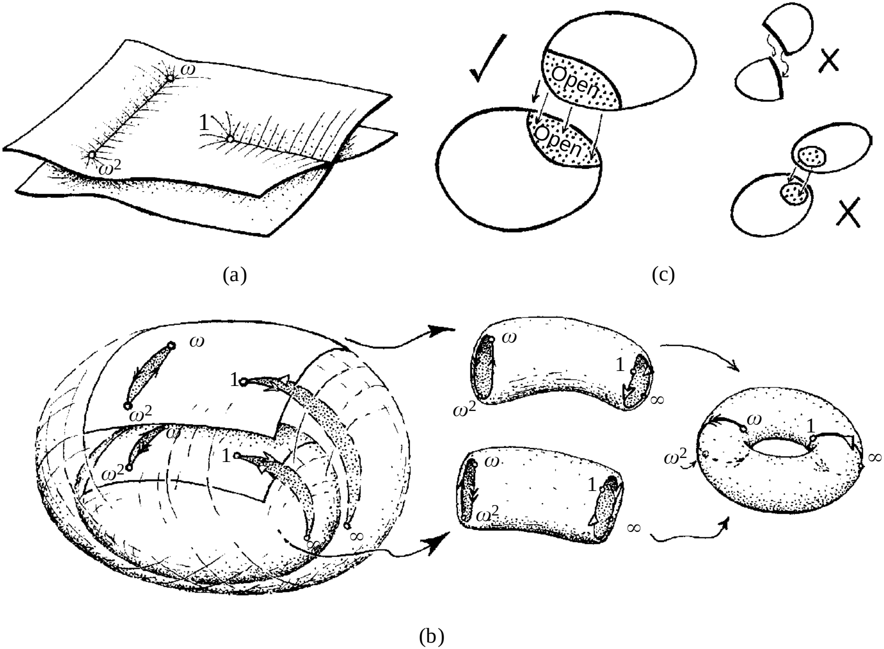


**Fig. 8.2** (a) Constructing the Riemann surface for $(1 - z^3)^{1/2}$ from two sheets, with branch points of order 2 at 1, $\omega$, $\omega^2$ (and also $\infty$). (b) To see that the Riemann surface for $(1 - z^3)^{1/2}$ is topologically a torus, imagine the planes of (a) as two Riemann spheres with slits cut from $\omega$ to $\omega^2$ and from 1 to $\infty$, identified along matching arrows. These are topological cylinders glued correspondingly, giving a torus. (c) To construct a Riemann surface (or a manifold generally) we can glue together patches of coordinate space—here open portions of the complex plane. There must be (open-set) overlaps between patches (and when joined there must be no 'non-Hausdorff branching', as in the final case above; see Fig. 12.5b, §12.2).