How can we pack spheres in three-dimensional space with the highest density? This problem has a long, beautiful history that spans four centuries. The solution is to first arrange spheres into triangular layers which are then stacked upon one another. Each layer can sit in two possible positions, leading to an infinite number of stacking possibilities. This idea may also hold the key to a six-decade-long puzzle in solid state physics. As a rule, solids become more ordered when cooled. Lithium and sodium are the only known exceptions -- they lose structural order below a critical temperature. Their low-temperature structures are not conclusively known, with experiments producing conflicting results over decades. What makes lithium and sodium exceptional? Why do experiments produce inconsistent results? We propose an explanation in terms of close-packing of spheres. Due to a hidden gauge symmetry, any stacking configuration of Li and Na atoms has the same electronic energy. They form 'frustrated' solids where an infinite family of crystal structures compete with one another.

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