about 10^8 times higher than the concentration of nucleons in a white dwarf star. Neutrons and protons are not identical particles. The Fermi energy of the neutrons need not equal the Fermi energy of the protons. The concentration of one or the other, but not both, enters the familiar relation

$$\varepsilon_F = \frac{\hbar^2}{2M}(3\pi^2 n)^{2/3}. \tag{50}$$

For simplicity let us suppose that the number of protons is equal to the number of neutrons. Then

$$n_{\text{protons}} \approx n_{\text{neutrons}} \approx 0.05 \times 10^{39}\ \text{cm}^{-3}\ , \tag{51}$$

as obtained from (49) on dividing by 2. The Fermi energy is

$$\varepsilon_F \cong (3.17 \times 10^{-30})n^{2/3} \approx 0.43 \times 10^{-4}\,\text{erg} \approx 27\,\text{Mev}. \tag{52}$$

The average kinetic energy of a particle in a degenerate Fermi gas is $\frac{3}{5}$ of the Fermi energy, so that in nuclear matter the average kinetic energy is 16 Mev per nucleon.

BOSON GAS AND EINSTEIN CONDENSATION

A very remarkable effect occurs in a gas of noninteracting bosons at a certain transition temperature, below which a substantial fraction of the total number of particles in the system will occupy the single orbital of lowest energy, called the ground orbital. Any other orbital, including the orbital of second lowest energy, at the same temperature will be occupied by a relatively negligible number of particles. The total occupancy of all orbitals will always be equal to the specified number of particles in the system. The ground-orbital effect is called the **Einstein condensation.**

There would be nothing surprising to us in this result for the ground state occupancy if it were valid only below 10^{-14} K. This temperature is comparable with the energy spacing between the lowest and next lowest orbitals in a system of volume 1 cm^3, as we show below. But the Einstein condensation temperature for a gas of fictitious noninteracting helium atoms at the observed density of liquid helium is very much higher, about 3 K. Helium is the most familiar example of Einstein condensation in action.

Chemical Potential Near Absolute Zero

The key to the Einstein condensation is the behavior of the chemical potential of a boson system at low temperatures. The chemical potential is responsible