Four-Alpha Linear-Chain States in ^{16}O*

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Nuclei with large deformations are at the frontier in nuclear spectroscopy. It is expected that deformations above 1:3 may be possible in light nuclei due to the α-cluster structure. For example, the possibility of multi-α linear-chain configuration in light nuclei, such as the 4α linear-chain band starting around the 4α threshold energy region in ^{16}O, has been suggested experimentally [1].

Here we study 4α linear-chain states in ^{16}O in comparison with 3α states in ^{12}C by using the Generator Coordinate Method within a microscopic $N\alpha$-cluster model. In contrast to the previous theoretical works, we discuss the stability of the $N\alpha$ linear-chain structure by solving dynamics of $N\alpha$ systems. Also it is shown to be very important to take into account the orthogonality between the linear-chain states and other low-lying states including the ground state. This is achieved by diagonalizing the Hamiltonian matrix in a wide space which also covers low-lying levels including the ground state. The framework used here is based on the combination of the Generator Coordinate Method (GCM) and the Constraint Cooling Method [2] proposed in the framework of AMD in order to generate GCM basis which describes low-lying levels.

The linear-chain state of ^{12}C is hardly considered to be a stable state as we increase the number of the GCM basis states. Their components fragment to the levels over broad range of excitation energy, especially to the 0_2^+ state, and these couplings make a pure linear-chain state unstable.

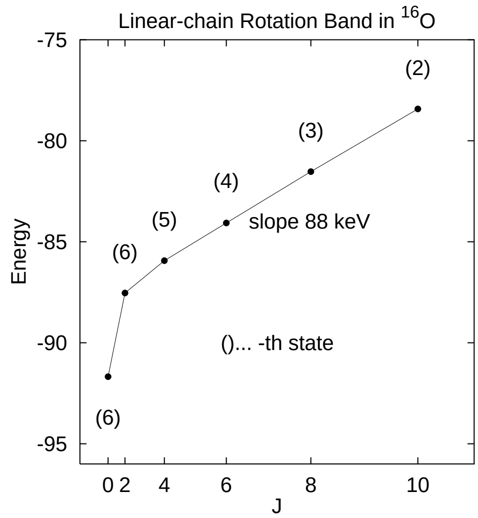

Figure 1: The rotational band of ^{16}O linear-chain state. The numbers show the order of excited state.

On the other hand, the 4α chain state in ^{16}O is hardly affected by low-lying states and persists to remain above the 4α threshold. The calculated moment of inertia of the 4α linear-chain rotational band (88 keV) reproduces the experimentally suggested value qualitatively. These conclusions are consistent with the previous work by Ikeda [3] where the stability against small vibrations around the equilibrium configuration is considered. Moreover, we have shown that the linear-chain state of ^{16}O may survive even after the couplings to the lower states are taken into account.

[1] P.Chevallier and F.Scheibling, Phys. Rev. **160** (1967) 160.
[2] Y.Kanada-En'yo and H.Horiuchi, Prog. Theor. Phys. **93** (1995) 115.
[3] K.Ikeda, N.Takigawa and H.Horiuchi, Prog. Theor. Phys. Suppl. Extra Number (1968) 464.

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