Structure of ^{31}Na studied by the Monte-Carlo shell model†

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Since anomalous properties of ^{31}Na concerning the mass[1] and the ground-state spin and magnetic moment[2] were observed in the 1970's, the structure of neutron-rich nuclei around $N = 20$ has attracted much interest, particularly concerning vanishing of the $N = 20$ magic number. Based on the Monte-Carlo shell model (MCSM),[3] we performed a systematic shell-model calculation for even-even $N \sim 20$ exotic nuclei with full mixing between the normal, intruder, and higher intruder configurations for the first time,[4] and gave a comprehensive picture of the region. As for odd-A nuclei, since we should adopt the J-compressed bases,[3] which require much computational time in the MCSM calculation, such a calculation was unfeasible until the Alphleet computer system[5] was introduced at RIKEN. In this report, the structure of a neutron-rich odd-A nucleus ^{31}Na, which is expected to be in the "island of inversion",[6] is studied by the MCSM with the Alphleet computer system.

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$$Y = \sum_{i=\infty} a_i + h + i + j + k + l + m \qquad (2)$$

The energy levels of ^{31}Na are shown in Fig. 1. The ground-state spin $3/2^+$ agrees with an experiment, in contrast to the sd-shell model prediction of $5/2^+$. The calculated magnetic moment of the ground state is $2.17\,\mu_N$ with free-nucleon g factors being consistent with the experimental value of $2.283\ (38)\,\mu_N$.[2] The present study shows that, while the ground state is dominated by the 2-particle 2-hole ($2p2h$) excitations from the $N = 20$ core, $4p4h$ and higher excited configurations are mixed and lower the ground-state energy by more than 700 keV. This energy gain gives rise to a better two-neutron separation energy. The first excited state obtained by the MCSM calculation is a $5/2^+$ state located at 310 keV, in good agreement with a recent measurement of 350 ± 20 keV.[7] On the other hand, this level was calculated to lie around 200 keV in the $0p0h + 2p2h$ truncation. A comparison between the truncated and full calculations clearly indicates the importance of the higher intruder configurations (*i.e.*, $4p4h$ and higher excited configurations from $N = 20$ core):[a] these configurations lower the ground state more than the first excited state, giving rise to a better agreement with experiment. The higher intruder

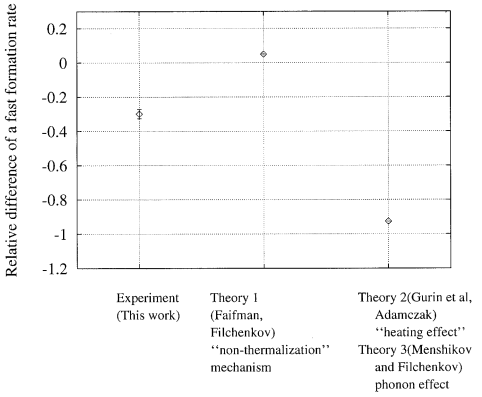

Fig. 1. Experimental energy levels of ^{31}Na (Exp.) compared with those of the MCSM calculation (MCSM).

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