

Bound excited states in ^{27}F *

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One of the most fascinating questions of nuclear structure physics is where the neutron dripline lies, and more importantly, why it is there. In this respect, an intriguing problem is that the dripline of fluorine isotopes is located at least 6 neutrons farther than that of the oxygen isotopes [1]. The naive assumption - according to which adding a proton to the oxygen nuclei makes the $\nu d_{3/2}$ state bound - can explain the bound nature of fluorine isotopes up to ^{29}F only. To make another pair of neutrons bound some kind of shell breaking mechanism like multi-particle-multi-hole excitations across major shells has to be assumed, since the last 2 neutrons above the $N = 20$ shell closure are far unbound in the spherical limit [2]. Neutron 2-particle-2-hole excitations across the $N=20$ shell are well known in this region, as they form the ground state of ^{32}Mg or ^{30}Ne nuclei. Whatever mechanism makes ^{31}F particle-bound, its traces should be visible in other fluorine nuclei, too. For instance, in ^{27}F the *psd* shell model [3], which can account for the properties of light fluorine nuclei, predicts the first excited state with spin $1/2^+$ at 2.0 MeV energy, much higher than the neutron separation energy of 1.3(4) MeV. On the other hand, some shell breaking or dripline effects acting in ^{31}F can make the energy of this state so low that it falls below the separation energy. According to recent Monte-Carlo shell model calculations, having a small $N=20$ shell gap, the presence of neutron excitations across the $N=20$ shell results in a bound excited state in ^{27}F [2]. To explore the traces of the mechanism which is expected to be responsible for the existence of ^{31}F in lighter fluorine nuclei, and to gain more information on its properties we have searched for bound excited states in ^{27}F .

We have carried out the experiment at RIKEN Accelerator Research Facility using (p,p') process in inverse kinematics. We observed two γ -ray lines in $^{25,26,27}\text{F}$ each, which establishes at least two bound excited states in these isotopes. The existence of a bound excited state in ^{27}F is a sign for insufficient size of the *psd* model space and consistent with the Monte-Carlo shell model [2] which allows for neutron cross shell excitations driven by the neutron pairing interaction. The presence of an additional bound state is puzzling. A new mechanism, such as lowering of a negative parity state through quadrupole correlations of proton and neutron cross-shell excitations or some sort of exotic clusterization should be considered to understand this unexpected phenomenon.

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