3 - 16 On the Masses of $A=54$ Isospin Septet and the Isobaric Multiplet Mass Equation*

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The NUBASE2020[1] recommends the masses of the $T=3$ isobaric analogue states (IASs) in ^{54}Fe, ^{54}Mn, and ^{54}Cr based on experimental measurements. Using the masses of these three IASs, the coefficients for the quadratic form isospin multiplet mass equation (IMME) of the $A=54$ isospin multiplet can be calculated. Then the mass excess of ^{54}Zn is predicted to be -4273(307) keV by the IMME. The ground-state mass excess value of ^{54}Zn can also be determined using the ground-state mass of ^{52}Ni[2] and the two-proton decay energy of ^{54}Zn[3,4]. This value is about ~ 2 MeV lower than the prediction from the quadratic form of the IMME, as shown in Fig. 1(a). The predictions from both the global and local mass models are in good agreement with the deduced mass value of ^{54}Zn, with an uncertainty of 300 keV. The cubic fit for the four members of the isospin septet yields a d coefficient of 18.6(27), significantly deviating from zero by more than 6.9σ, indicating a serious breakdown of the quadratic form of the IMME in the $A=54$, $T=3$ isospin septet.

To address this anomaly, we investigate the systematics of the coefficients of the IMME in isospin multiplets with $A \geqslant 16$ and $T \geqslant 3/2$, using the approach introduced in Ref. [5]. The ratio of the b and c coefficients, $|b/c|$, is nearly a linear function of $(A-1)$, as shown in Fig. 1(b). In the $A=54$, $T=3$ isospin multiplet, the quadratic IMME coefficients a, b, and c are extracted using four combinations of three IASs. The $|b/c|$ ratios are also displayed in Fig. 1(b), revealing that only exclusion of the $T=3$ IAS in ^{54}Fe yields $|b/c|$ values that align with the general trend of the systematics, suggesting that the breakdown of the IMME in the $A=54$, $T=3$ isospin multiplet may be attributable to the mass of the $T=3$ IAS in ^{54}Fe. We suggested that two scenarios could be responsible for such an anomaly: the one is concerned with the mis-assignment of the $T=3$ IAS in the $T_z=1$ nucleus ^{54}Fe, and the other could be due to the extremely strong isospin mixing. For detailed discussion, please refer to the published paper[6].

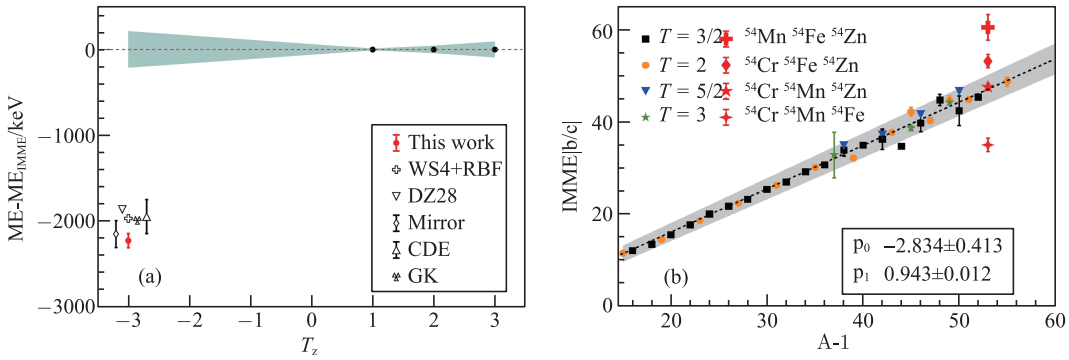

Fig. 1 (color online) (a) The mass difference between experimental values and predictions for ^{54}Zn. The shading area represents the uncertainty from the IMME prediction, (b) Dependence of the quantity $|b/c|$ on $A-1$ for all isospin multiplets. The four red symbols represent results from $A=54$, $T=3$ isospin multiplets. The gray shading area represents the 3σ error band of the fitted linear function.

References

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* Foundation item: National Key R&D Program of China (2018YFA0404401, 2016YFA0400504) and National Natural Science Foundation of China (11975280, 11905259)