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Search of Chiral Doublet Bands at ^{186,188}Ir

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Abstract.

We report a new experimental results about candidates for chiral-twin bands in the mass $A \sim 190$ region for the doubly-odd ^{186,188}Ir nuclei. In this region the odd neutron is at the top of the $\nu i_{13/2}$ subshell, while the valence proton tends to occupy the $\Omega = 1/2$ states of the $\pi h_{9/2}$ subshell or the $(\pi i_{13/2})$. A prolate-oblate shape transition has been observed in this region, and as a result triaxial shapes might be expected for some of the Ir nuclei. A stable triaxial shape is prerequisit for existence of chiral rotation. The experiments were performed at the WNSL of Yale University using of the YRAST Ball spectrometer.

1 Introduction

Nuclear chirality has both a dynamical origin and geometrical nature. The last is based on the distinction between left and right-handed coordinate systems fixed to the triaxial nucleus. Chirality is suggested to occur in triaxial doubly-odd nuclei with substantial asymmetry (γ=30°), for which the Fermi surface of the valence proton (neutron) is near the bottom of high-j shell, while the neutron is at the top of a high-j shell. If for these specific configurations, the nucleus rotates around an axis, tilted with respect to the principal planes, the chiral symmetry will be broken spontaneously in intrinsic frame of reference. The experimental fingerprint of this motion would be two degenerate $\Delta I=1$ rotational bands will originate from above mentioned left and right-handed solutions. The chiral solution in ^{188}Ir is analogous to the one in ^{134}Pr [1] but the unique parity occupied orbitals are shifted with one shell up.

The main goal of the experiment was to search for nuclear chiral twin bands. The ^{186,188}Ir isotopes lie in the region between the well-deformed nuclei and the nuclei with a spherical shape. For example, the different spectroscopic quadrupole moments of ^{186}Ir and ^{188}Ir are -2.548(31)[5^+] and +0.484(6) (b) [1^-] respectively, according to [2].

2 Experiments and Results for ^{186}Ir

High spin states in the doubly odd-Ir nuclei has been populated from the fusion reaction ^{15}N(^{176}Yb,4n). The ^{15}N beam was accelerated by Tandem Van de Graff accelerator to energy 82 MeV and the target was made of ^{176}Yb foil with 6.65 mg/cm^2 thickness. The YRAST Ball spectrometer consists 5 HpGe Clover detectors (90° with respect to the beam line), also 17 HpGe detectors (126,5° and 160°) and 7 LEPS detectors for the low energy gammas (50°). The data analysis was performed by using the RADWARE software.

The level scheme of ^{186}Ir shown in Figure 1 was expanded considerably compared to the previous studies [3]. The following features of this level scheme

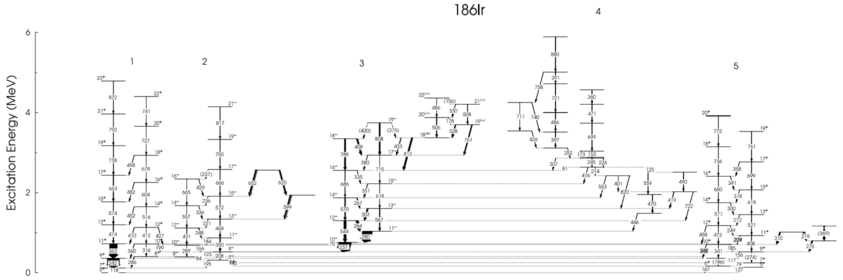

Figure 1. Level scheme of ^{186}Ir as deduced from the ^{15}N(^{176}Yb,4n) reaction at 82 MeV.

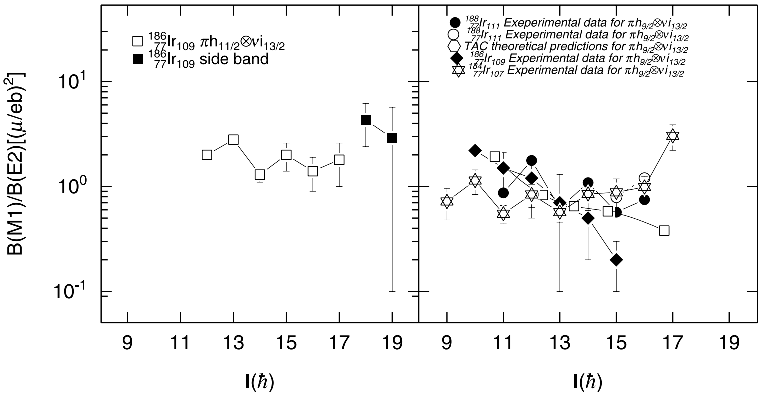

Figure 2. Experimental *B(M1)/B(E2)* ratios for $\pi h_{9/2}\otimes\nu i_{13/2}$ and $\pi h_{11/2}\otimes\nu i_{13/2}$ bands in the doubly-odd Ir-isotopes. On the right plot: TAC predictions for $\pi h_{9/2}\otimes\nu i_{13/2}$ band - solid line.

need to be mentioned:

(i) – we have extended the $\pi h_{11/2} \otimes \nu i_{13/2}$ through the first band crossing, which occurs at a rotational frequency $\hbar\omega \sim$ of 0.38 MeV, and can be interpreted as a result of the rotational alighment of a $\pi h_{9/2}$ pair, in agreement with our previous results for ^{185,187}Ir [4,5].

(ii) – no chiral partner was observed for this band within the detection limit of the YRAST Ball spectrometer.

(iii) – irregular structure of most probably single-particle origin competes at high-spins with collective rotation.

3 Investigations and Results of ^{188}Ir

A chiral twin $\Delta I=1$ bands with negative parity have been suggested in ^{188}Ir, having the $\pi h_{9/2} \otimes \nu i_{13/2}$ configuration (Figure 3).

The ^{186}W(^{7}Li,5n) reaction at 52 MeV was utilized to populate the high-spin states in ^{188}Ir. The ^{7}Li beam was delivered by the ESTU Tandem van de Graff accelerator at the WNSL at Yale University. The tagret consisted of three stacked foils of ^{186}W, each of thickness 0.3 mg/cm^2.

Mixed *M1/E2* links, as well as similar ratios for the reduced transitions probabilities in the both bands have been observed, which reflects their common underlying structure. In the same study, a new $\Delta I=1$ band, connected to the known $\pi h_{11/2} \otimes \nu i_{13/2}$ band in ^{186}Ir has been found, but the energy difference with the yrast band is twice as large. We have compared the experimental observations

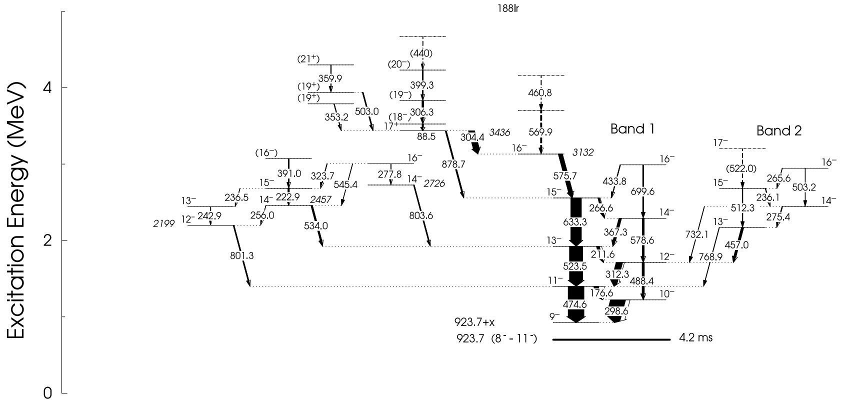

Figure 3. The $\pi h_{9/2} \otimes \nu i_{13/2}$ band in ^{188}Ir.

with TAC calculations, which are reasonable for ^{188}Ir, where the model yields a chiral solution, while for ^{186}Ir there is no chiral solution.

The experimental results for the *B(M1)/B(E2)* ratios (Figure 2) for the $\pi h_{9/2} \otimes \nu i_{13/2}$ bands in ^{186,188}Ir as obtained in the present experiment are displayed in Figure 2. The *B(M1)/B(E2)* ratio was determined from the experimental obtainig of the branching ratio $I_\gamma(M1)/I_\gamma(E2)$, where $I_\gamma(M1)$ and $I_\gamma(E2)$ are the experimental values of the intensity for *M1* and *E2* tranistions in one Δ*I=1* band.

The behaviour of this odd-even staggering is similar to that for $\pi h_{9/2} \otimes \nu i_{13/2}$ band in ^{188}Ir. Moreover the 3D TAC model suggests a chiral solutions in ^{188}Ir for the $\pi h_{9/2} \otimes \nu i_{13/2}$ band. The chiral band in ^{188}Ir is the first one, which was discovered at the $A \sim 180$ region.

4 Summary

We have studied high-spin states in ^{186,188}Ir. For ^{188}Ir we have observed two degenerate bands of the same frequency. They were interpreted as chiral twin bands - such structure has not been found in ^{186}Ir within the sensitivity of our experiments. This is understood as due to the appearence of the triaxiality in ^{188}Ir, while is this effect is less pronounced in ^{186}Ir.

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