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ANGULAR MOMENTUM TRANSFER IN DEEP INELASTIC SCATTERING

EXPERIMENT AND THEORY

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ABSTRACT

The measured γ-ray multiplicities as a function of exit channel kinetic energy and mass asymmetry for the reactions Au, Ho, Ag + 620 MeV Kr are compared with a diffusion calculation based exclusively upon particle transfer and which reproduces the Z distributions as well as the angular distributions and function of Z. The model correctly predicts the energy and Z dependence of the γ-ray multiplicities thus lending support to the one body model on one hand and to the angular momentum fractionation along the mass asymmetry coordinate on the other.

The measurement of γ-ray multiplicities in deep inelastic processes as a function of fragment energy, angle and atomic number is one of the most powerful tools to study detailed aspects of the reaction mechanism. From this kind of measurements one learns not only about the angular momentum transfer from orbital to intrinsic rotation but also about the angular momentum fractionation along the mass asymmetry coordinate [1].

Detailed measurements have been performed at several energies on the reactions Au, Ho, Ag + Kr [1]. For all cases the γ-ray multiplicities have been measured as a function of fragment energy, angle and atomic number. Some of the available data are shown in Fig. 1 and Fig. 2. A rapid rise of the multiplicities is observed with decreasing fragment energies over the quasi-elastic region. The multiplicities remain approximately constant over the deep inelastic region with a slight decrease at the lowest energies [Fig. 1]. The Z dependence for all of the reactions is very weak and the rise, naively expected from rigid rotation, fails to appear [Fig. 2].

A diffusion model, based exclusively upon particle transfer is used to calculate the Z distribution, the angular distribution for each Z, and the angular momentum transfer as a function of energy loss for each Z [2]. The agreement between theory and experiment for the Z distributions and the angular distributions for each Z is excellent and has been presented elsewhere [3]. As shown in Fig. 1, the increase of the γ-ray multiplicities with decreasing kinetic energy is reproduced quantitatively in all the cases. This seems to indicate that particle transfer alone is sufficient to explain the energy dissipation and the angular momentum transfer. If excitation of collective modes is present, it must closely mimic particle transfer both in the energy dissipation and in the angular momentum transfer. The Z dependence of the γ-ray multiplicities is accurately reproduced both in the quasi-elastic and in the deep inelastic region [Fig. 2]. The v-shaped pattern centered at the projectile Z visible in the quasi-elastic component reflects the increase of the average number of particle exchanges and transfers as one moves away from the projectile Z. The lack of rise of the γ-ray multiplicity at low Z's in the deep inelastic component is due to angular momentum fractionation[1]. On one hand the ℓ-dependence of the interaction time forces the high ℓ-waves to concentrate at atomic numbers close to that of the projectile while it allows the low ℓ-waves to spread over a broader Z range. On the other hand the ℓ-dependence of the driving force along the mass asymmetry coordinate further contributes to the angular momentum fractionation. At low angular momenta, the potential energy, at the projectile Z, gently slopes down towards symmetry. In this case a sizable amount of diffusion occurs towards low Z's. At high angular momenta, the potential energy steeply decreases as one moves toward symmetry. In this case, little or no diffusion can occur towards the low Z's. Consequently only the low angular momenta populate the fragment with Z below the projectile. Because of this the γ-ray multiplicity does not increase with decreasing Z's even though the rigid rotation limit is attained.

References

[1] M. M. Aleonard, et al., Phys. Rev. Lett. 40, (1978) 622

[2] J. Sventek and L. G. Moretto, Phys. Rev. Lett. 40, (1978) 697

[3] L. G. Moretto, J. Phys. Soc. Japan 44, (1978) 361 Suppl.

Figure Captions

Fig. 1 Dependence of the angle and Z integrated γ-ray multiplicities upon exit channel kinetic energy. The solid lines are the calculated values.

Fig. 2 Dependence of the angle integrated γ-ray multiplicities upon Z for both quasi-elastic (open circles) and deep inelastic (solid circles) components. The solid lines represent the calculated values.

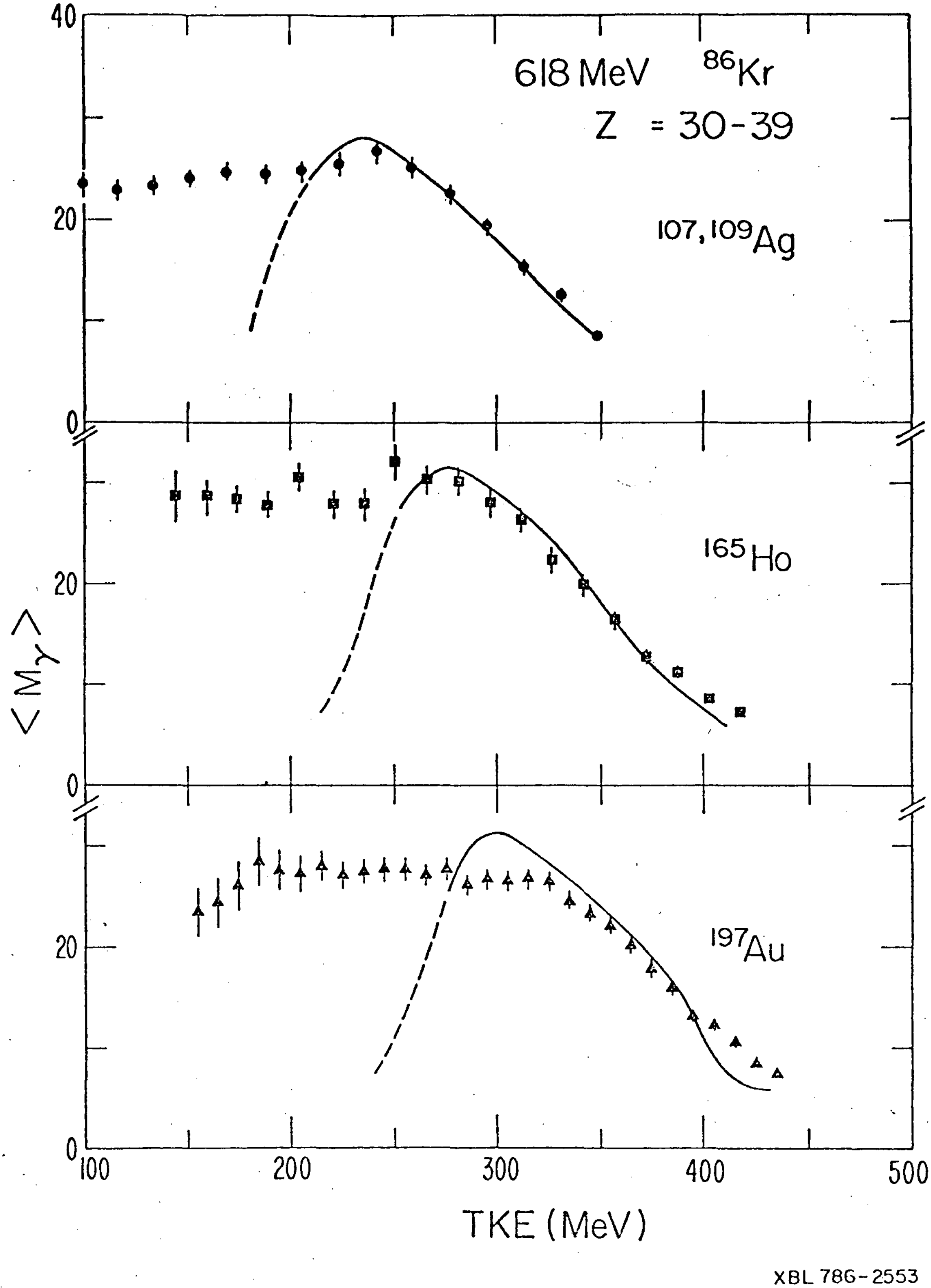
618 MeV ^{86}Kr
Z = 30-39
^{107,109}Ag
^{165}Ho
^{197}Au
40
20
0
20
0
20
0
100
200
300
400
500
< M_γ >
TKE (MeV)
XBL 786-2553

Fig. 1

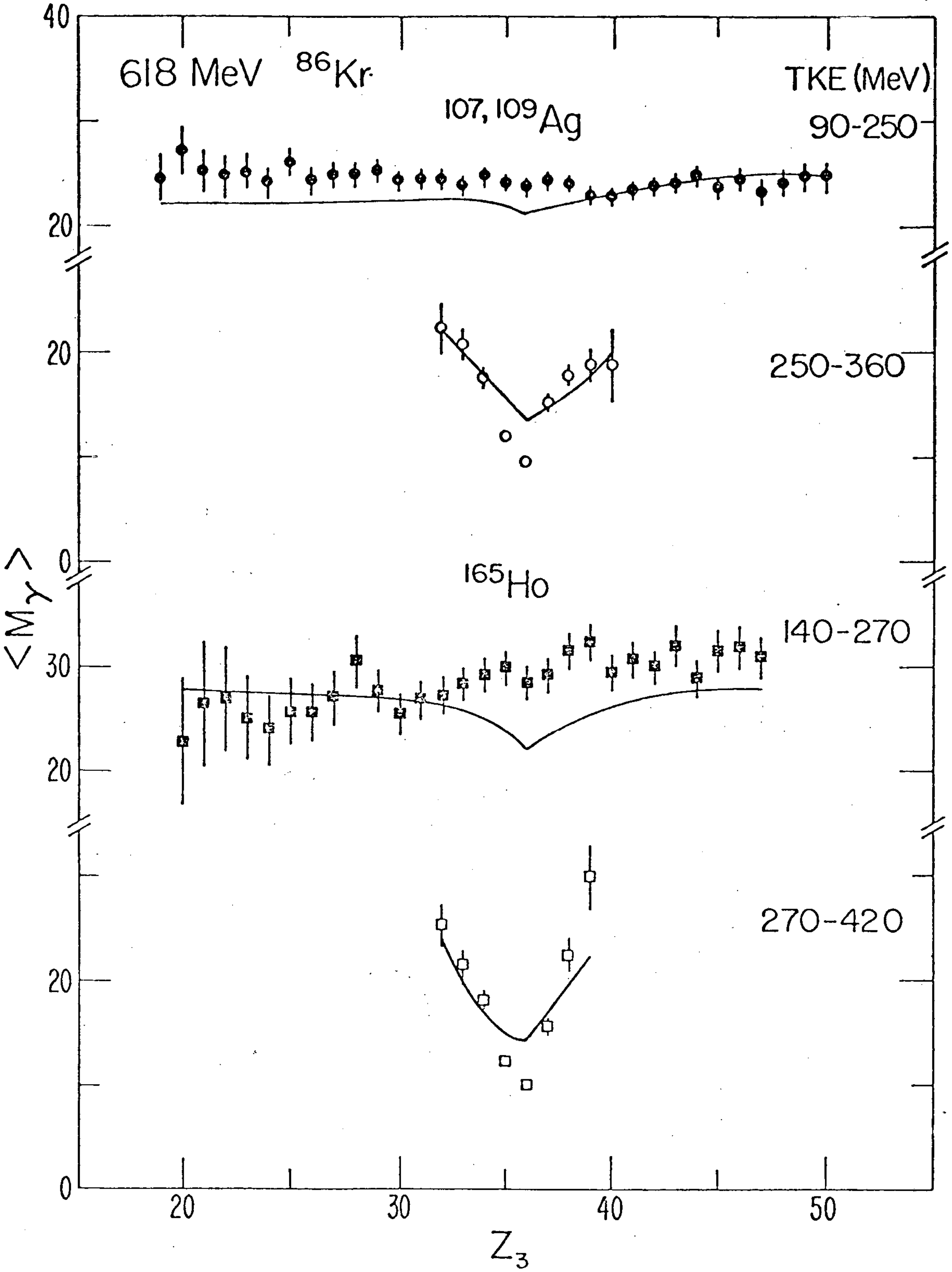

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Fig. 2

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