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Nuclear moments of short-lived isomeric states – experimental techniques, recent studies and ideas for future developments

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The lifetimes of nuclear states span many orders of magnitude, requiring experimental techniques to be tailored to both their production mechanisms and their half-lives. Nuclear magnetic moment studies rely on the interaction between nuclear spins and external electromagnetic fields. Consequently, the feasibility of such measurements is determined by the state's lifetime and the strength of the fields to which the nuclei can be exposed.

For isomeric states with half-lives between ~1 ns and a few microseconds, nuclear moment studies are typically based on the observation of spin precession in an external electromagnetic field. The Time Dependent Perturbed Angular Distribution (TDPAD) technique has been the method of choice for several decades, particularly for isomers produced in fusion–evaporation reactions. However, this production mechanism is not well suited for accessing isomeric states in neutron-rich nuclei far from stability. To overcome this limitation, projectile-fragmentation reactions have been developed over the last two decades as an alternative approach, enabling studies of isomers with half-lives from roughly 200 ns up to a few microseconds. A brief overview of these developments at various international facilities will be presented, along with examples of recent measurements and a discussion of the limitations of the method.

Isomeric states with even shorter lifetimes (< ~200 ns) remain inaccessible via projectile fragmentation. To address this gap, we have recently begun exploring the application of the Time Dependent Perturbed Angular Correlation (TDPAC) technique for such short-lived states. The prospects for advancing this approach and the challenges associated with its implementation will also be discussed.

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