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Review

Laser spectroscopy for nuclear structure physics

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ABSTRACT

High-resolution laser spectroscopy is an established powerful tool in the study of nuclear shape, size and multipole moments. Measurements of the hyperfine structures and isotope shifts in the atomic spectra of radioactive nuclei provide unique insight into the evolution of the nuclear macroscopic shape and microscopic structure. These measurements can be made with high precision and high sensitivity and applied directly on-line at radioactive nuclear beam facilities. Recent measurements, advances at facilities and the future direction of the field are reviewed. A summary of experimental data is presented.

Contents

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1. Introduction

High-resolution laser spectroscopy has long been established as a powerful tool in the study of nuclear shape, size and multipole structure. The "Hyperfine spectroscopy of radioactive atoms" was first reviewed in 1979 by Jacquinot and Klapisch [1]. When deployed at radioactive beam facilities, where long chains of isotopes on both sides of the valley of beta stability can be produced, optical techniques still provide a unique opportunity to study changes in the structure of nuclear ground (and isomeric) states.

Otten [2] produced a comprehensive review of the field in 1989. This was updated in 1995 by Billowes and Campbell [3] and then in 2003 by Kluge and Nörtershäuser [4]. New experimental techniques, most notably radiofrequency ion beam coolers and bunchers, trapped atoms, and the greatly increased use of specialist ion sources formed the basis of a 2010 review by Cheal and Flanagan [5].

In this report we review the field with a focus on recent and projected progress with respect to measurements and facility developments, taken as that since the 2010 Cheal and Flanagan review [5]. Recent reported results, those since 2010, are highlighted in Table 1. Techniques are reviewed in Section 3 and developments at facilities are discussed in Section 4.

The reported results provide model-independent measures of the nuclear spin, multipole moments and radial extent of the charge distribution. The new results are concentrated towards the lighter and heavier mass regions of the nuclear chart. In many of the works new results for nuclear moments are reported and, where of structural pertinence, considered