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Laser spectroscopy frontiers at the top of the nuclear map

Optical spectroscopy constitutes the historical path to accumulate basic knowledge on the atom and its structure. Former work enabled identifying optical spectral lines for elements up to fermium (Z=100) [1], which still can be obtained in miniscule amounts for offline experiments. A great leap forward in this research field was recently achieved with successful laser spectroscopy of the element nobelium (Z=102) [2]. Despite a complete lack of tabulated spectral lines and production yields from nuclear fusion reactions of about one atom per second, it was still possible to search for, locate, and characterize optical transitions in this element. The experiments provided powerful benchmarks for atomic model calculations [3] and enabled information on the atomic nucleus to be obtained independent of nuclear models [4].

Beyond nobelium, solely predictions of the atom's structure exist, which in general are far from sufficient to reliably identify atoms from spectral lines. One of the major difficulties in atomic model calculations arise from the complicated interaction between the numerous electrons in atomic shells, which necessitate conducting experiments on such exotic quantum systems. The experiments, however, face the challenging refractory nature of the elements, which lay ahead, coupled with shorter half-lives and decreasing production yields.

In my talk, I will show the recent results as well as new concepts of laser spectroscopy of even heavier atomic species such as lawrencium (Z=103) and the superheavy element rutherfordium (Z=104) at the extremes of nuclear existence.

References

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