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Toruń, 18.09.2025

city, date

Full name of doctoral student: Marcin Umiński

Album no.:

PESEL no.:

DOCTORAL DISSERTATION ABSTRACT

Scientific discipline: Physical Science

Title of the doctoral dissertation: Decaying Feshbach resonances in complex ultracold systems

Doctoral dissertation abstract: The presented dissertation is a study of decaying Feshbach resonances in complex ultracold systems. It focuses on, in particular, their presence, impact and controllability in select molecular systems. By analysing said systems and theoretical calculations incorporating several numerical methods and computational frameworks, precise results were obtained, answering vital questions on how the resonances behave and what are the mechanisms behind them.

Study of NO^++H_2 addressed bound state structure and incorporated the asymmetric top model, providing a methodological foundation for later parts of the thesis.

The third chapter presents an ongoing study of helium and lithium, where refined numerical methods were applied to complex optical potentials. In this system, Li+Er bound states can be optically coupled to the continuum, giving rise to decaying Feshbach resonances. Such features, including Penning ionization, were observed, confirming both their presence and tunability.

Next part of the work focuses on Li+Er and K+Dy molecules. Those two systems consist of light alkali metals and heavy, magnetic lanthanides. Thorough studies of structures and sensitivity to factors, like interaction potentials, provided an understanding of the resonance spectra, bound state structures and the role of anisotropy in resonant behaviour.

Lastly, a study of Sr-SrOH molecules was conducted, analysing resonance and bound state patterns, highlighting the role of couplings between channels in Feshbach resonances.

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This thesis presents deep insight into Feshbach resonances, explaining their lossy character and tunability.

doctoral student's signature