

Atomic structure calculations of np^3 , nd^6 , and nd^8 highly charged ions

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The rich energy configurations of highly charged ions (HCIs) offer numerous optical transitions between the ground state and the low-lying excited states, which have wide applications for astronomy, plasma, frequency metrology, and precision measurements. Generally, the compact size of the HCIs makes them insensitive to external fields. Strong relativistic effects and high ionization energies make the HCI clock transitions highly sensitive to variation of the fine structure constant and dark matter searches [1-3]. In this talk, we will introduce our investigation of energies and spectroscopic properties of the neutral atoms P through Mc belonging to Group-15, singly ionized atoms S^+ through Lv^+ of Group-16, and doubly ionized atoms Cl^{2+} through Ts^{2+} of Group-17 [4]. These ions have the np^3 configurations, and their forbidden transitions among the low-lying fine-structure splitting states are found in the optical region. The high-accuracy calculation of atomic properties such as lifetimes, Landé g_J factors, and magnetic dipole (A) and electric quadrupole (B) hyperfine structure constants of the fine-structure partner states with np^3 configurations are reported. We will discuss d^6 and d^8 open-shell highly charged Ions as distinguished candidates of ultra-stable optical clocks [5]. We have examined the energy level-crossing rule of the low-lying states of the nd^6 and nd^8 HCIs. They offer at least two sets of clock transitions with quality factors about 10^{16-18} and fractional uncertainties due to major systematics effects are below the 10^{-19} level. These clock transitions also show very sensitivity for probing fundamental phenomena like possible temporal variation of the fine structure constant and local Lorentz symmetry invariance. Various spectroscopic properties of the np^3 , nd^6 , and nd^8 highly charged ions reported by using atomic structure calculations based on three different relativistic many-body methods can be useful in guiding experiments to measure them in the future and probing the potential of the methods employed.

References

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