

# Magnetic field induced transition rates in Ne- and Be-like ions for plasma diagnostics and E1M1 two-photon decay rate determination

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**Synopsis** We report on theoretical results of magnetic field induced transitions (MITs) in Ne- and Be-like ions without nuclear spin for two applications. Firstly, MITs are promising candidates in the determination of magnetic fields in plasmas. In our work on Ne-like ions we present accurate theoretical MIT rates for  $2p^6\ ^1S_0 - 2p^53s\ ^3P_{0,2}$  [1]. Furthermore, for Be-like ions, it has been proposed to extract the rate of the E1M1 two-photon transition  $2s^2\ ^1S_0 - 2s2p\ ^3P_0$  by measuring the lifetime of the  $^3P_0$  state using a storage ring, which involves an external magnetic field. The MIT rates are carefully evaluated and shown to be of the same order as the E1M1 rates [2].

The effects of magnetic fields are important in many astrophysical or laboratory plasmas and their strengths are crucial plasma parameters. It is well-known that the interaction between the magnetic field and an atom (or ion) causes spectral lines to split into groups of lines (Zeeman splitting), which can be used to determine the magnetic field strength in a plasma. On the other hand, the magnetic interaction also breaks the symmetry of an atomic system allowing atomic states with the same magnetic quantum number and parity to mix and bring about “unexpected” lines to appear in the spectra. We will refer to these as magnetic field induced transitions (MITs).

In this work we have calculated MIT rates in Ne- and Be-like ions without nuclear spin for two applications, as described in the following paragraphs. We perform large-scale multiconfiguration Dirac-Hartree-Fock calculations using GRASP2K [3] to determine the unperturbed wavefunctions, followed by an evaluation of the mixing due to the external magnetic field using perturbation theory and HFSZEEMAN [4] to build the final  $M$ -dependent wavefunctions.

*Ne-like* In 2003, Beiersdorfer *et al.* [5] identified a MIT in Ne-like Ar. Furthermore they illustrated that the MIT can be used as a diagnostic of magnetic field strength for high-temperature plasmas. In the present work [1] we report theoretical results for magnetic field induced  $2p^6\ ^1S_0 - 2p^53s\ ^3P_{0,2}$  E1 transitions in Ne-like ions with zero nuclear spin ( $I = 0$ ) between Mg III and Zn XXI as well as in Ne I. We show that it is, in contrast to earlier estimations in the case of Ne-like Ar [5], important to include both “perturber” states,  $2p^53s\ ^3P_1$  and

$2p^53s\ ^1P_1$ , in order to produce reliable transition rates. We investigate the MITs along the isoelectronic sequence and evaluate their strength compared to competing M1 and M2 decay channels.

*Be-like* In beryllium-like ions, the lowest lying excited state is the metastable state  $2s2p\ ^3P_0^o$  which for isotopes with zero nuclear spin, only can decay through higher order transitions where the strongest one is the E1M1 two-photon transition. The lifetime of the  $2s2p\ ^3P_0$  level has recently been measured for Be-like Xe using a storage ring. This measurement involves an external magnetic field of about 0.75 T, and the MIT must be taken into consideration when extracting the E1M1 rate [6]. In order to support this the MIT rate is carefully evaluated along the isoelectronic using a similar method as in the Ne-like project, and shown being of the same order as the E1M1 rate [2].

## References

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