Excitation Dynamics of the Beryllium Hypersatellite

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The study of excitation and emission associated with single core vacancies is central to VUV radiation physics. Much less attention has been paid to the creation and annihilation of multiple core holes. This is not due to the lack of scientific motivation; such studies have been deemed impractical only due to their low cross sections. In atomic physics there is a high current interest in so-called hollow states, few-electron systems where more than one of the inner electrons are promoted to higher levels. The investigation of photoexcitation and decay dynamics of such states leads to new insights regarding the fundamentals of electron correlation.

With electron excitation, soft X-ray emission associated with an electron from the valence band filling one of two vacancies in a core level have been been observed earlier. Such transitions have been termed hypersatellites, and it has been realized that the comparison of the hypersatellite and the main band gives direct information on the influence of the core hole on the electronic structure, and provides a critical test of the final state rule.As excitation mechanism, shake processes as well as semi-classical models involving double-hits of the incoming electrons have been considered. We present the first preliminary study of excitation-energy dependence of the photon-excited soft X-ray hypersatellites, emission from double core hole states in beryllium metal. The shape of the hypersatellite emission is substantially broader than the main band, and has the intensity redistributed towards lower energies. This is in general agreement with the change in the local partial density of states upon the creation of a core hole.

Within our experimental accuracy the shape of the hypersatellite is independent of the excitation energy. In contrast, the overall intensity is critically dependent on excitation energy. The threshold for double ionization is situated at 262 eV, and the intensity raises monotonically towards higher energies.

After correction for self-absorption we find that the single-to-double-hole fluorescence cross section ratio at higher energies is around 0.15. This number does not directly reflect the ionization cross sections. We expect that the single-to-double ionization ratio should be close to the asymptotic value for the helium atom, 0.04. We believe that the remaining factor is due to an increased fluorescence yield for the double holes relative to the single holes. Such an increase has been predicted for low-Z elements.