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# All-orders inclusion of relativistic effects in atomic structure theory

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Despite the enormous success of theoretical atomic physics over the past 100 years, the majority of atomic structure calculations treat electron-electron interactions completely non-relativistically through the Coulomb interaction. Although this captures the leading order behaviour of the interactions and is suitable for approximately non-relativistic systems, for heavy or highly-charged ions this is known to be an insufficient starting point. This can partly be remedied through the inclusion of relativistic corrections to the Coulomb interaction, which to leading order is represented by the Breit interaction, and which captures the magnetic interactions, as well as retardation effects. While the Breit interaction can be included into high-precision atomic structure calculations, it can only currently be done to the second order of perturbation theory, where in heavy ions it is known to significantly modify energy corrections. Furthermore, in certain of these ions, such as thorium and radium, there is a wide deviation in the theoretical prediction of the energy of certain states and experimental measurements, which could possibly be related to the large contribution from the Breit interaction at second order. By using the Feynman diagram approach to perturbation theory, I have included the Breit interaction into an important class of many-body effects that are summed exactly to all orders in the Coulomb interaction. By doing so, I have shown that although the deviation from experiment is not completely resolved in the absolute values of energy levels, the fine structure intervals in these systems are greatly improved by the Breit interaction when it is included to all orders in perturbation theory.

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