Superatomic states in transition metal clusters: A new paradigm for control of magnetism at the nanoscale

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The concept of a 'superatom', a metal cluster in which delocalised electron states form shells analogous to those of an individual atom, has been extremely successful in explaining the structure of clusters constructed of metals with *s* or *p* electron density. In this work, we explore the extent to which transition metal clusters can be superatomic, and the ways in which this depends on the relative energetic proximity of the *s* and *d* shells, as well as the extension of the atomic *d* shell. To do so, we consider a range of transition metals from left to right, and top to bottom, of the *d* block. We show that the superatomic model is indeed relevant to a number of transition metals, once the different possible behaviours of the *d* electrons are well understood. The consequent connection between electronic shell structure and local magnetic moments has implications for the use of superatoms as tunable building blocks for novel magnetic materials.