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Electronic Structure of Actinides under Pressure

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The series of heavy radioactive elements known as the actinides all have similar elemental properties. However, when the volume per atom in the condensed phase is illustrated as a function of atomic number, perhaps the most dramatic anomaly in the periodic table becomes apparent. The atomic volume of americium is almost 50% larger than it is for the preceding element plutonium. For the element after americium, curium, the atomic volume is very close to that of americium. The same holds also for the next elements berkelium and californium. Accordingly from americium and onwards the actinides behave very similar to the corresponding rare-earth elements - a second lanthanide series of metallic elements can be identified. This view is strongly supported by the fact that all these elements adopt the dhcp structure, a structure typical for the lanthanides. The reason for this behavior is found in the behavior of the 5f electrons. For the earlier actinides, up to and including plutonium, the 5f electrons form metallic states and contribute most significantly to the bonding. In Np and Pu they even dominate the bonding, while all of a sudden they become localized in Am, very much like the 4f electrons in the lanthanide series, and contribute no longer to the cohesion. This withdrawal of 5f bonding gives rise to the large volume expansion between plutonium and americium. This difference between the light and heavy actinide suggests that it would be most worthwhile to strongly compress the transplutonium elements, thereby forcing the individual 5f electron wave functions into strong contact with each other (overlap). Recently high pressure experiments have been performed for americium and curium and dramatic crystal structure changes have been observed. These results and other high pressure data will be discussed in relation to the basic electronic structure of these elements.