Electronic structure from relativistic quasiparticle self-consistent $GW$ calculations\textsuperscript{1}
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Most theoretical studies of topological insulators (TIs) are based on tight-binding descriptions and density functional theory (DFT). But recently, many-body calculations within the $GW$ approximation attract much attention in the study of these materials. We present an implementation of the quasiparticle self-consistent (QS) $GW$ method where the spin-orbit coupling (SOC) is fully taken into account in each iteration rather than added a posteriori. Within the all-electron FLAPW formalism, we show DFT, one-shot $GW$, and QSGW calculations for several, well-known TIs. We present a comparison of the calculations to photoemission spectroscopy and show that the $GW$ corrected bands agree much better with experiment. For example, we show that Bi$_2$Se$_3$ \cite{1,2} is a direct gap semiconductor, in contrast to what was believed for many years by interpreting experimental results on the basis of DFT and that small strains in Bi can lead to a semimetal-to-semiconductor or trivial-to-topological transitions \cite{3}. Quasiparticle calculations for low-dimensional systems are still very demanding. In order to study the topological surface states with an approach based on $GW$, we use Wannier functions to construct a Hamiltonian that reproduces the many-body band structure of the bulk, and that is used to construct a slab Hamiltonian. With this approach, we discuss the effect of quasiparticle corrections on the surface states of TIs and on the interaction between bulk and surface states. \cite{1} I. Aguilera et al., PRB 88, 045206 (2013), \textit{ibid.}, PRB 88, 165136 (2013). \cite{2} M. Michiardi et al., PRB 90, 075105 (2014). \cite{3} I. Aguilera et al., PRB 91, 125129 (2015).

\textsuperscript{1}Work was funded by the Virtual Institute for Topological Insulators of the Helmholtz Association and carried out in collaboration with Irene Aguilera, Gustav Bihlmayer, and Christoph Friedrich.