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Quantum-confined holes: More spin for your buck![1]

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The physical properties of charge carriers in crystalline solids are dictated largely by the material's band structure. Typically, band electrons from the (lowest) conduction band behave very similarly to free electrons in vacuum, only with parameters such as their mass and g-factor adjusted. In contrast, holes from the (upper-most) valence band show a much richer behavior owing to their intrinsic spin-3/2 degree of freedom and this spin's strong coupling to the crystal momentum of holes. In a two-dimensional (2D) quantum well, size quantisation induces an energy splitting between heavy-hole (HH) and light-hole (LH) subbands. The existence of this HH-LH *splitting* makes it tempting to consider HH and LH degrees of freedom separately, in particular in situations where only the highest (generally HH-like) 2D hole subband is occupied. In my talk, I will focus on how such an approach overlooks intriguing differences in the mesoscopic and many-particle properties exhibited by quantum-confined holes as compared with their conduction-electron counterparts. Recent results on the density response [1] and spin susceptibility of 2D holes will be presented to illustrate the ramifications of ubiquitous HH-LH *mixing*. I will also discuss how the temporal modulation of Rashba spin splitting in hole nanostructures generates larger-magnitude spin currents than in corresponding band-electron systems [2]. Finally, Andreev reflection of holes in a p-type-semiconductor – superconductor hybrid system will be considered [3], which also exhibits novel behavior due to band mixing.

[1] T. Kernreiter, M. Governale, and U. Zulicke, New J. Phys. **12**, 093002 (2010).
[2] T. Kernreiter, M. Governale, A. R. Hamilton, and U. Zulicke, Appl. Phys. Lett. **98**, 152101 (2011).
[3] D. Futterer, M. Governale, U. Zulicke, and J. Konig, Phys. Rev. B **84**, 104526 (2011).

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