Integer quantum Hall effect in a multivalley PbTe quantum well

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PbTe is a IV-VI semiconductor material which is characterized by a narrow energy gap, large values of dieletric constant and g factor, a small effective mass and a Fermi surface composed by four equivalent strongly anisotropic ellipsoids of revolution with their main axis along the $\langle 111 \rangle$ directions. The large dielectric constant is responsible by an effective screening of charged impurities, defects, and dislocations, which added to a small effective mass results in a high electron mobility. These make PbTe quantum wells a model system for studying the quantum Hall effect in the absence of electron-electron interactions.
We have measured the integer quantum Hall effect in a 10nm PbEuTe/PbTe/PbEuTe quantum well grown by molecular beam epitaxy on a (111) BaF_2. The inverse Hall resistance ($1/R_{xy}$) and longitudinal resistance (R_{xx}) show clearly defined signature of the integer quantum Hall effect with well defined plateau in $R_{xy}(B)$ and a zero resistance state in $R_{xx}(B)$. The measured electron density from the inverse period of the Shubnikov de Haas oscillations is $n_s = 2.23 \times 10^{12}$ cm^{-2} compared with $n_s = 2.28 \times 10^{12}$ cm^{-2} measured from the low field Hall resistance slope. In contrast to previous work, our PbTe quantum well sample shows no sign of parallel conduction.
For a heterostructure grown along the [111] crystallographic direction, the fourfold degeneracy of the Fermi surface is lifted due to the confinement. The large anisotropy and multivalley nature give rise to a complex density of states, leading to a nontrivial behavior of the electronic transport as a function of the magnetic field. Due to the occupation of a singly degenerate longitudinal valley and the three fold degenerate oblique valleys, the Hall resistance is quantized for an unconventional sequence of filling factors. As the magnetic field is swept the quantized Hall conductance can change by 1, 3 or 4 e^2/h.