The quantum Hall ferromagnet at the zero filling factor is investigated for the \( n=0 \) Landau levels of the two dimensional massless Dirac fermions under strong magnetic field. We consider a twofold valley degeneracy which occurs in graphene and alpha-(BEDT-TTF)\(_2\)I\(_3\) under pressure\([1,2]\).

In the case of no tilt of the Dirac cones, the long-range Coulomb interaction exhibits, in the \( n=0 \) Landau levels, the SU(2) valley-pseudospin symmetry even at order \( O(a/l) \), in contrast to the case of non-zero Landau levels, where \( a \) and \( l \) represent the lattice constant and the magnetic length, respectively. This characteristic comes from a fact that zero-energy states in a particular valley are restricted to only one of the spinor components, whereas the other spinor component is necessarily zero. In this case, the easy-axis pseudospin ferromagnetism has been theoretically suggested for the \( n=0 \) Landau levels\([3]\).

If the tilt of the Dirac cones, which arises naturally in alpha-(BEDT-TTF)\(_2\)I\(_3\)\([4]\), is taken into account, one obtains a non-zero value of the second component. The "backscattering" term\([5]\), which is responsible for an easy-plane pseudospin ferromagnetism (XY-type), therefore becomes non-zero. Moreover, it is suggested that the phase fluctuations of the order parameters can be described by the XY Heisenberg model leading to Kosterlitz-Thouless transition\([6]\) at lower temperature. In view of these theoretical results, experimental findings in resistivity in alpha-(BEDT-TTF)\(_2\)I\(_3\) are discussed.