Ground state of the spin-1/2 XYZ-Heisenberg-Ising two-leg ladder

T. Verkholyak[a] and J. Strečka[b]

[a] *Institute for Condensed Matter Physics, NAS of Ukraine, 1 Svientsitskii Street, 79011 L'viv-11, Ukraine, E–mail: werch@icmp.lviv.ua*

[b] *Department of Theoretical Physics and Astrophysics, Institute of Physics, P. J. Šafárik University, Park Angelinum 9, 040 01 Košice, Slovak Republic, E–mail: jozef.strecka@upjs.sk*

The quantum spin-$\frac{1}{2}$ two-leg ladder with the anisotropic XYZ Heisenberg intra-rung and Ising inter-rung interactions is treated by means of a rigorous approach based on the unitary transformation. The particular case of the considered model with $X-X$ intra-rung interaction resembles the quantum compass ladder with additional frustrating diagonal interactions. Using the appropriately chosen unitary transformation the model under investigation may be reduced to the transverse Ising model with composite spins and one may subsequently find the ground state quite rigorously. We obtain the ground-state phase diagram and analyze the interplay of the competition between several factors: the XYZ anisotropy of the Heisenberg intra-rung coupling, the Ising interaction along legs, and the frustrating diagonal Ising interaction. The investigated model shows an extraordinary diverse ground-state phase diagrams including several unusual quantum ordered phases, disordered paramagnetic phase, as well as, the discontinuous or continuous quantum phase transitions between those phases.