Frustrated S = 1/2 square lattice systems in complex Vanadium oxides

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The frustrated spin square lattice system has attracted strong theoretical attention since an interesting phase diagram and unusual ground states are expected depending on the relation between $J_1$ (nearest neighbor exchange) and $J_2$ (diagonal frustrating exchange). However, experimental studies are very limited because of the absence of appropriate compounds. The first example for the realization of such a lattice, Li$_2$VO(Si/Ge)O$_4$, was found only quite recently. Further on, the ratio $J_1/J_2$ in this compound is controversial, more recent investigations suggest the frustration to be very weak. We found a new series of compound, AA’VO(PO$_4$)$_2$, with A, A’ = Zn, Pb, Sr, Ba, where the structural data as well as susceptibility $\chi(T)$ and specific heat $C(T)$ data suggest such a frustrated square lattice to be realized. However, a detailed analysis of our $\chi(T)$ and $C(T)$ data using high temperature series expansion demonstrates that in these compounds, $J_1$ is ferromagnetic while $J_2$ is antiferromagnetic, $|J_2|$ being larger than $|J_1|$. These systems are thus the first examples for a frustrated spin square lattice system with a ferromagnetic nearest neighbor exchange. The frustration is changing quite strongly with the A and A’ cations, being strongest in SrZnVO(PO$_4$)$_2$ where $|J_1| \approx |J_2|$. Our results prompted the theoretical investigation of the $J_1$-$J_2$ model with ferromagnetic $J_1$, since such a constellation was yet barely considered.