De Haas-van Alphen oscillations in ZrSiS and HfSiS

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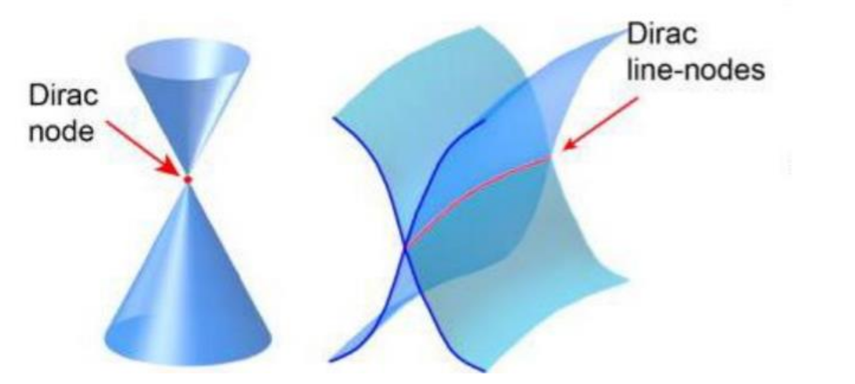
Nodal line semimetal

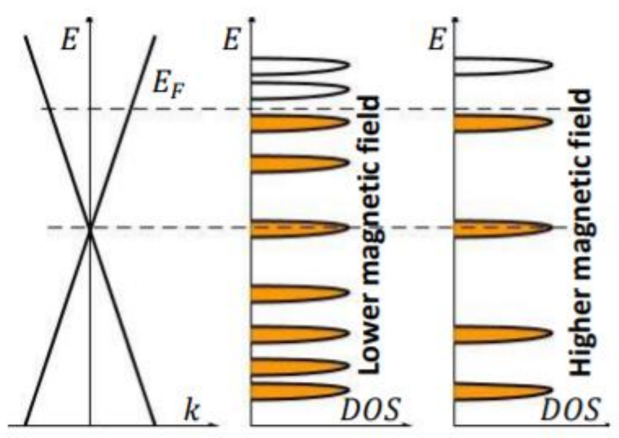
Dirac nodal fermions physics:
- Nontrivial topology
- Topologicaly protected surface states



Symmetry protected band degeneracies which form lines
Linear energy dispersion -> Dirac line nodes

Quantum oscillations

- Electrons in strong magnetic field
  -> Landau levels
- Increasing field leads to periodical crossing of Landau levels and E_F
  -> Oscillations of physical quantities with 1/B
- Frequency of oscillations determined by the extremal cross sections of FS and plane normal to external field



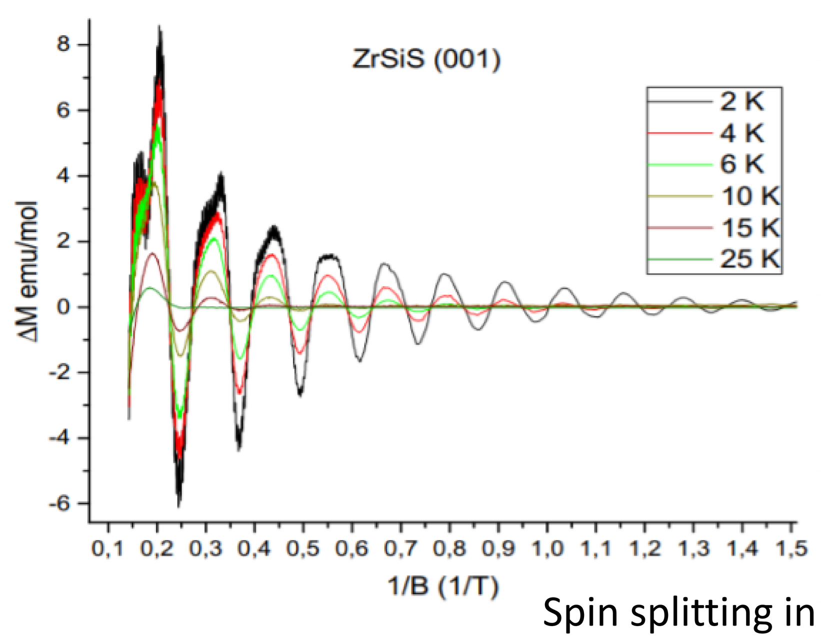
Lifshitz-Kosevich equation

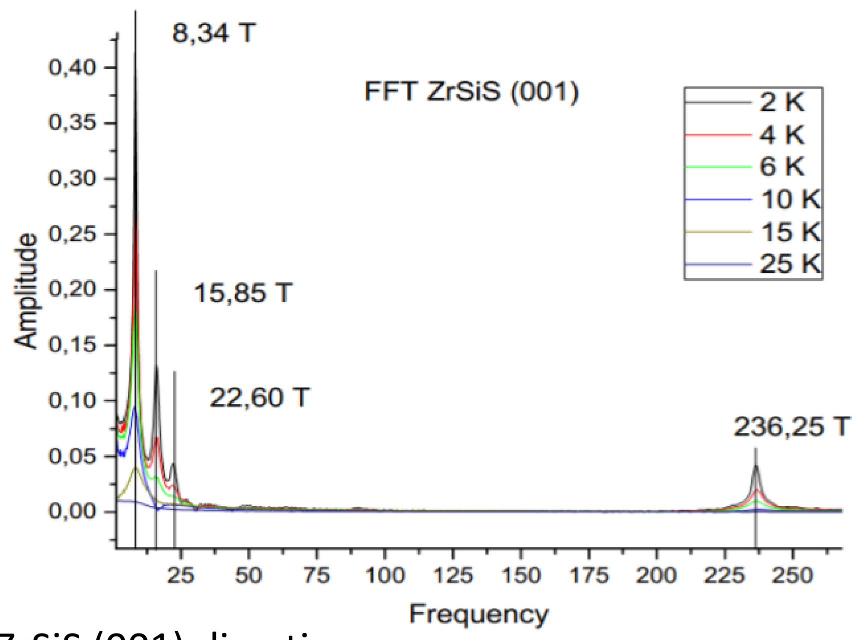
$$\Delta X(B,T) = A_0 A_T A_D A_S \left(\frac{B}{F}\right)^{\frac{1}{2}} \cos\left[2\pi \frac{F}{B} + \phi\right]$$

$$A_T = -\frac{2\pi^2\left(\frac{k_B T}{\hbar\omega_C}\right)}{\sinh\left(2\pi^2\left(\frac{k_B T}{\hbar\omega_C}\right)\right)} \qquad A_D = \exp\left(-2\pi^2\left(\frac{k_B T_D}{\hbar\omega_C}\right)\right) \qquad A_S = \cos[\pi g m_e / 2 m_c]$$

Quantum oscillations in magnetization -> de Haas-van Alphen oscillations

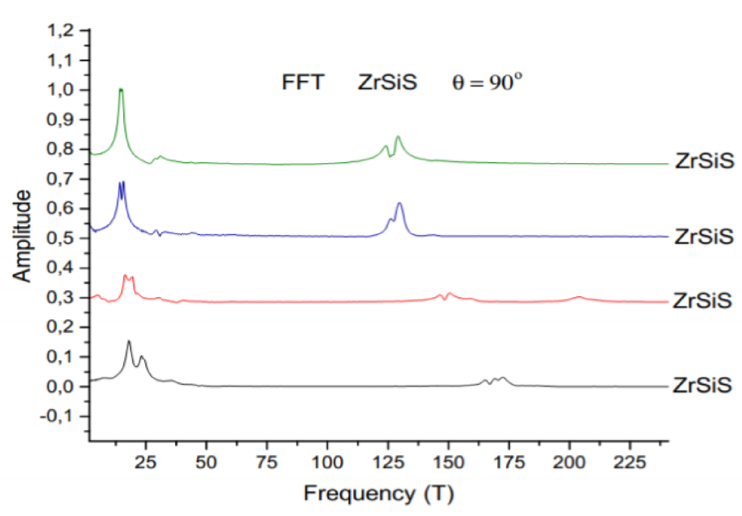
ZrSiS

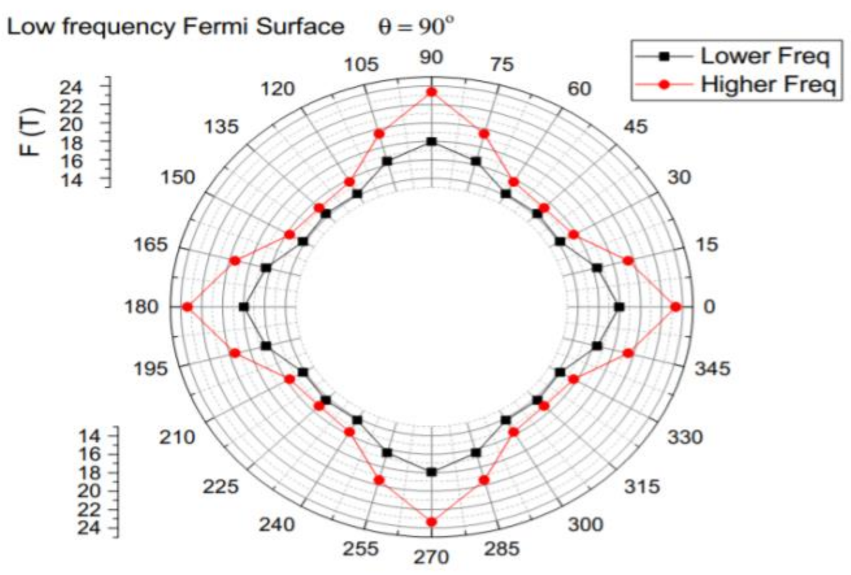




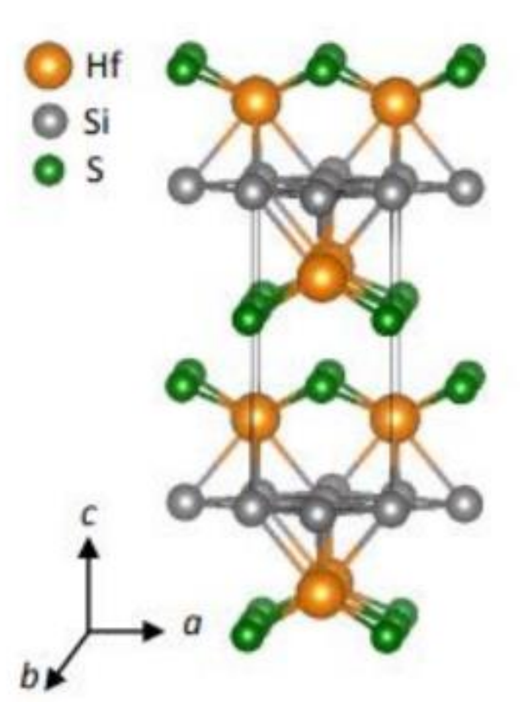
Spin splitting in ZrSiS (001) direction

Reconstructing low frequency Fermi Surface by rotating the sample



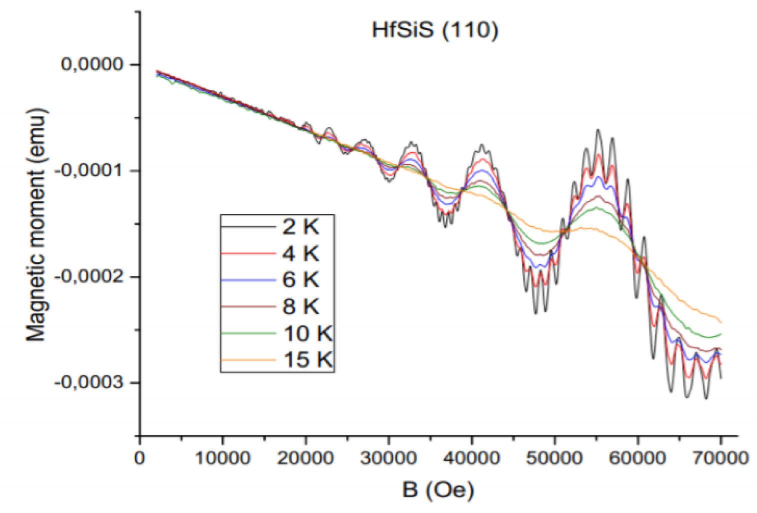


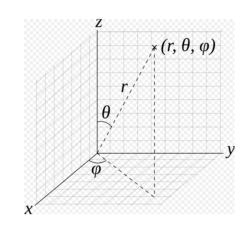
$Hf_xZr_{1-x}SiS$



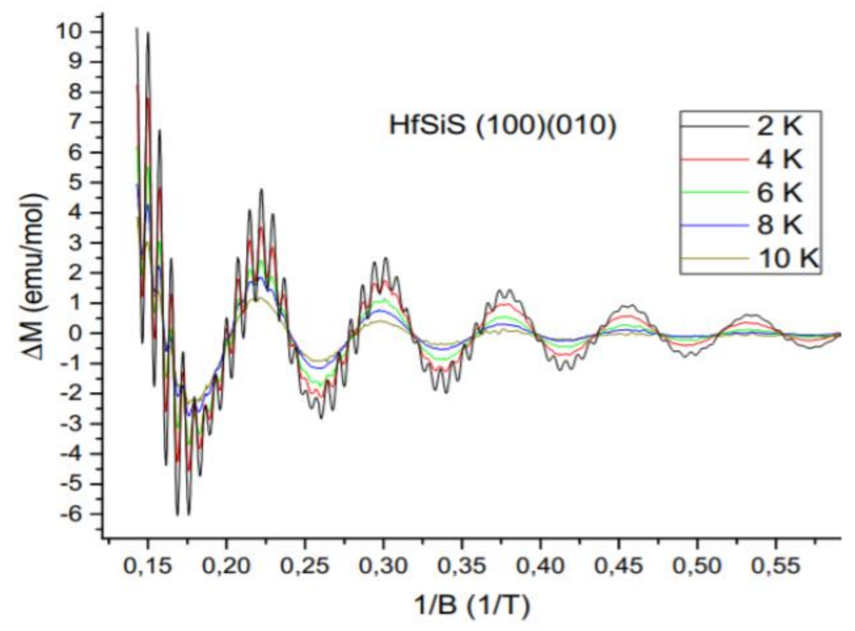
HfSiS and ZrSiS crystalize in same structure
-> possibility for substitution

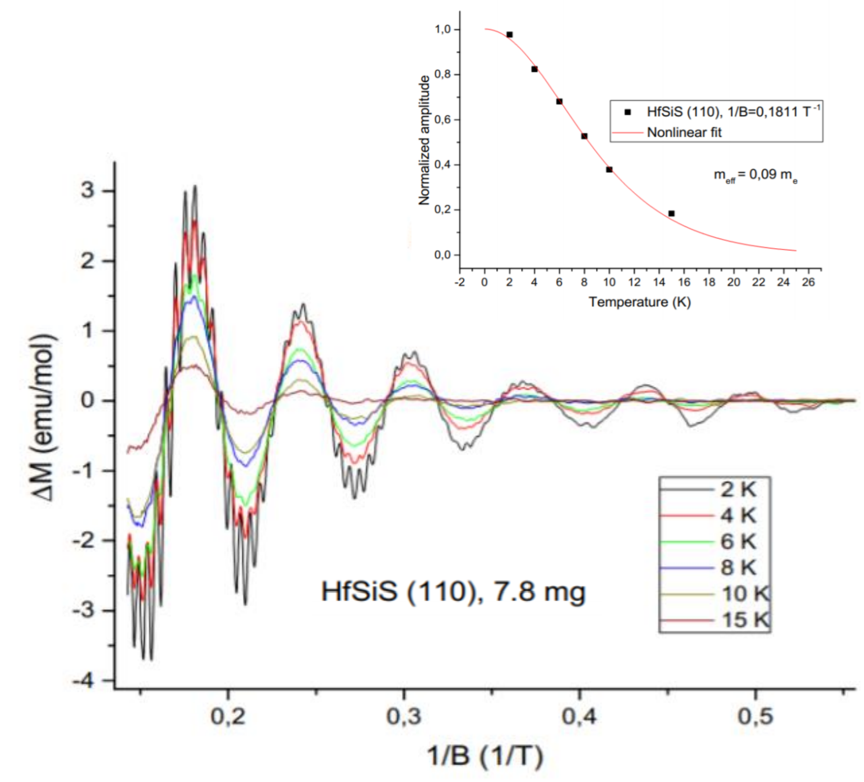
Magnetization data acquiered with SQUID magnetometer up to 7 T for different ϕ and θ considering crystal symmetry





HfSiS

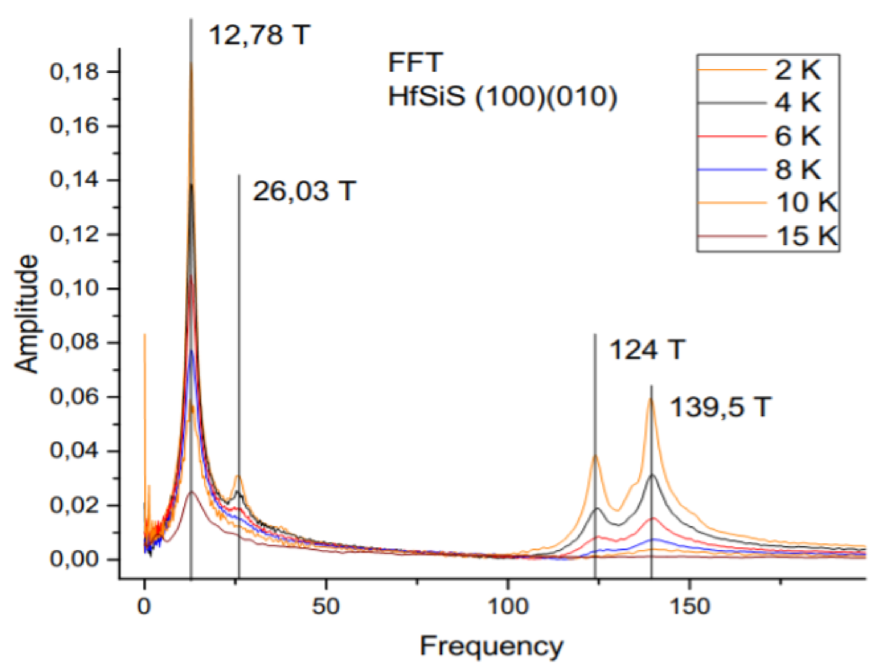


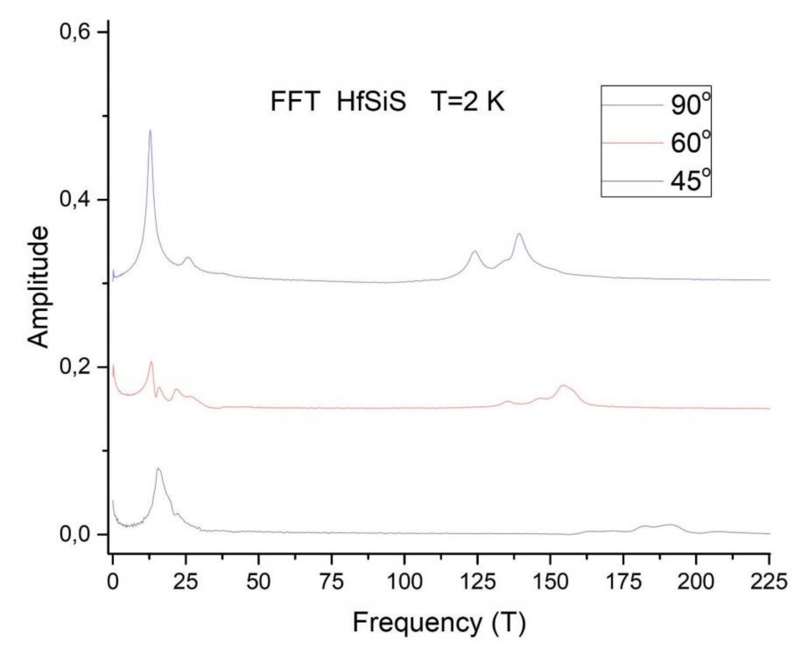


Interference of 'two groups' of frequencies

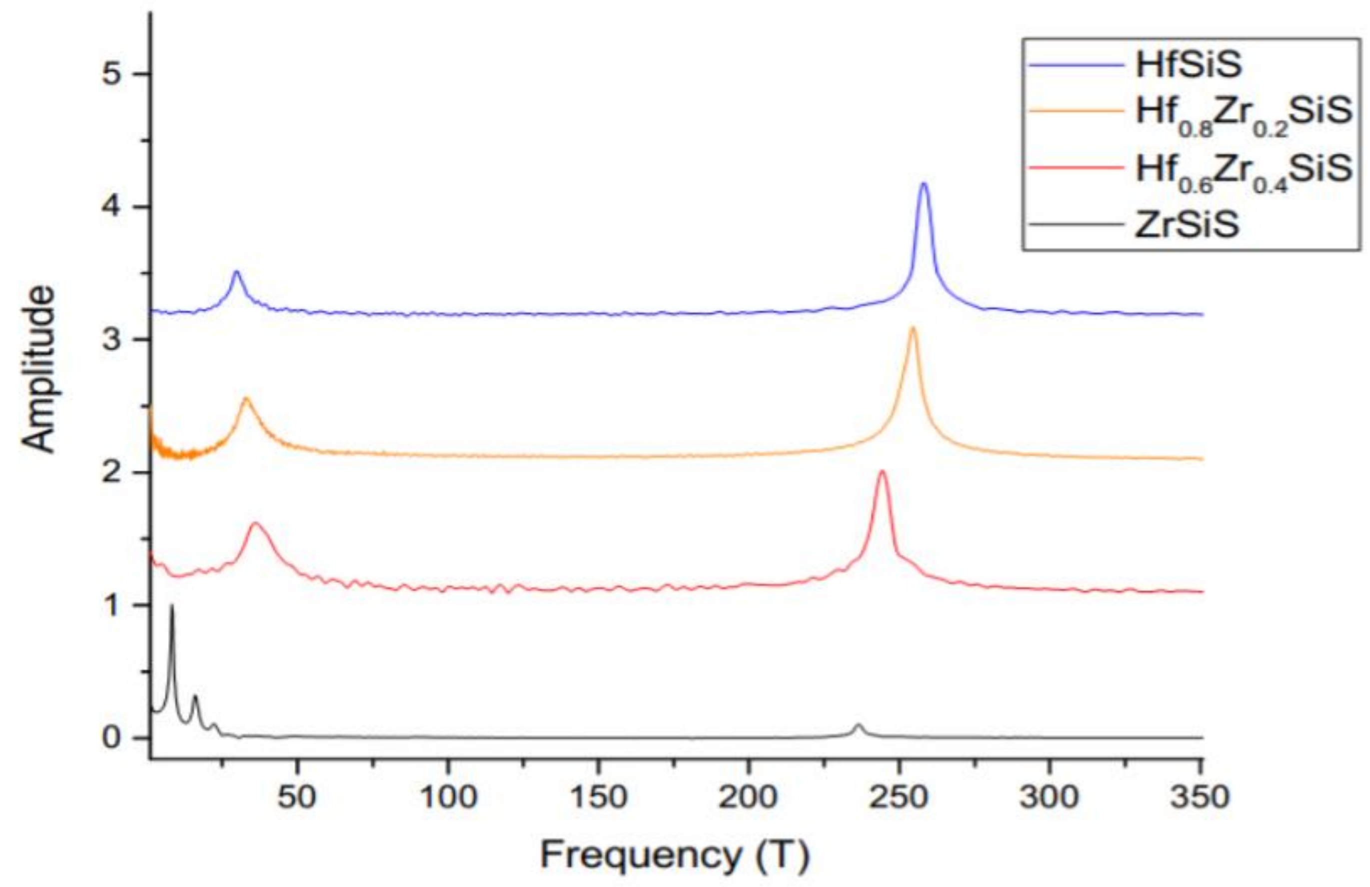
Effective mass can be obtained using LK equiation

Propagation of frequencies for different ϕ





$Hf_xZr_{1-x}SiS$



Supstitution effect on oscillations frequency in (001) direction
Measurement and synthesis of remaining compositions in progress

Conclusion

- Magnetization in $Hf_xZr_{1-x}SiS$ single crystal was measured with SQUID magnetometer up to 7 T for different angles ϕ and θ
- FFT of quantum oscillations shows two sets of frequencies: low frequencies (up to 40 T) and high frequencies between 100-250 T
- FS of selected crystal can be reconstructed from frequencies
- Measurement and synthesis of remaining $Hf_xZr_{1-x}SiS$ compositions in progress

This work has been fully supported by Croatia Science Foundation under HRZZ projects 6216 and HRZZ IP-2018-1-8912

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