Exercises for Space Plasma Physics: IV. Kinetic equations

1. What is the difference between the Vlasov-, Boltzmann- and Fokker-Planck equation?

2. Why do physicists use the Fokker-Planck equation in fully ionized plasmas instead of the Boltzmann equation used for normal gases?

3. How does the entropy $S = -\sum_\alpha \int f_\alpha \ln f_\alpha \, d\mathbf{x}\, d\mathbf{v}$ evolve in a Vlasov Maxwell system?

4. In the lecture we showed the Mayer-Cluster-expansion for the two-particle distribution function $f^{(2)}_{\alpha,\beta}$. Can you imagine, how the corresponding expansion for a three particle-distribution function $f^{(3)}_{\alpha,\beta,\gamma}$ looks like? Are three-particle correlations assumed to be more or less important than two-particle correlations in space plasmas?

5. Check if the following distribution functions are stable or unstable:

   - Drifting Maxwellian (with Drift velocity $\mathbf{u_D}$):

   $$f(\mathbf{v}) \propto \exp\left(-\frac{m\,(\mathbf{v}-\mathbf{u_D})^2}{2\,k_b\,T}\right)$$

   - Maxwellian with a non-thermal feature like a drifting beam

   $$f(v) = \exp\left(-\frac{m\,v^2}{2\,k_b\,T}\right) + \epsilon \exp\left(-10 \cdot \frac{m\,(\mathbf{v}-\mathbf{u_D})^2}{2\,k_b\,T}\right)$$