

# Exercises for The Physics of Galaxy Clusters

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Exercise sheet 7

To be uploaded to Moodle. Remember to put your name on the document. You may work in groups of up to 2 but every student should hand in his/her own solution sheet and indicate clearly who contributed to it. The exercises are based on the lecture notes. Thus, **studying the lecture notes carefully** will help you immensely in solving the exercises!

## 1. OoM: Sunyaev-Zel'dovich effect (10 points)

Assume a galaxy cluster at redshift  $z = 1$  with  $k_B T = 5$  keV, radius  $R = 3$  Mpc, cluster electron number density  $n_e = 10^{-4} \text{ cm}^{-3}$ , and a line-of-sight velocity  $v_r = 300 \text{ km s}^{-1}$ . Calculate to order of magnitude:

- (a) The amplitudes of the thermal and kinematic SZ effect,  $y$  and  $w$ .
- (b) The integrated quantities of the thermal and kinematic SZ effect,  $Y$  and  $W$ .
- (c) How would  $Y$  and  $W$  change if the gravitational mass of the cluster doubled?

## 2. Review of the lectures for the oral exam (20 points)

Read through the lecture notes. There may still be parts that you have not yet fully understood so that you would not be able to answer them during the oral exam. Please write down at least 8 questions to the following main topics (at least 2 questions per topic):

- (a) Overview and Background
- (b) The Dark Component
- (c) The Baryonic Component
- (d) Cluster Astrophysics and Cosmology across wavelengths