Formalities.
Solutions should be handed in Monday 09.10., latest 14.00 via inspera. If inspera is not working, send your solutions either by email, put them in my mailbox (in D5-166) or hand them in before the lectures.

1. Summary.
Write a 2 pages executive summary of the lectures concentrating on radiation, stars and stellar structure.

2. From fluid to stars.
Show how the hydrostatic equilibrium equation follows as a special limit from the equations of fluid dynamics.

3. Lane-Emden.
a.) Write a simple ODE solver (using e.g. the Runge-Kutta method) and find numerically the solution of the Lane-Emden equation for $n = 1.5$ and 3. Plot the solutions together with the analytical one for $n = 0, 1$ and 5.
b.) The cases $n_a = 1.5$ and $n_r = 3$ are good approximations for MS stars with adiabatic and radiative energy transport. Explain why $n_r > n_a$ is expected.
c.) Show that the total mass of the $n = 5$ solution is finite (although $R_5 \to \infty$).

4. StatStar.
a.) Choose a mass M in-between the values in the attached table. Calculate and plot $M(r)$, $T(r)$, $L(r)$ and $P(r)$ as function of r for a star with a homogeneous composition given by $X = 0.7$, $Y = 0.292$ and $Z = 0.008$. Repeat this for $X = 0.7$, $Y = 0.29$ and $Z = 0.01$. For a "HR diagram" with the appropriate boundary conditions for the two cases see the attached tables. [Note: The program was by purpose written as simple as possible. This implies that the convergence is sub-optimal – don't expect it too work on the first try. Also the values in the innermost layer may be unreliable.]
b.) Which model has the higher central temperature? Density? Why?
c.) Which model has the largest energy production in the core? Why?
d.) Which model has the lower effective temperature and luminosity? Why?

Table S10.3: Input data for Problem 10.27. All models have $X = 0.7$ and $Z = 0.008$.

M ($M_\odot$)	T_e (K)	L ($L_\odot$)	M ($M_\odot$)	T_e (K)	L ($L_\odot$)
0.50	2287.7	0.0215	4.50	18906.2	516.0
0.60	2862.3	0.0570	4.75	19498.7	624.2
0.70	3465.5	0.1300	5.00	20069.0	745.7
0.75	3788.5	0.1890	5.25	20601.5	880.5
0.80	4109.3	0.2650	5.50	21072.5	1029.0
0.90	4755.5	0.4940	5.75	21585.8	1192.0
1.00	5402.0	0.8590	6.00	22089.0	1372.0
1.10	6117.0	1.4170	6.50	22982.7	1778.9
1.20	6802.3	2.2200	7.00	23810.0	2253.0
1.30	7458.6	3.2900	7.50	24613.0	2794.0
1.40	8062.9	4.6800	8.00	25366.5	3409.0
1.50	8644.6	6.4080	8.50	26052.5	4097.0
1.60	9146.0	8.5000	9.00	26722.0	4857.0
1.70	9596.3	11.0000	9.50	27330.0	5696.0
1.75	9852.6	12.5000	10.00	27933.0	6607.0
1.80	10074.2	14.1000	10.50	28523.0	7601.0
1.90	10546.0	17.8000	11.00	29109.5	8675.0
2.00	10952.6	22.0500	11.50	29648.0	9824.0
2.25	11950.9	35.8000	12.00	30149.0	11050.0
2.50	12903.1	55.1000	12.50	30627.0	12354.0
2.75	13811.0	80.7000	13.00	31096.0	13727.0
3.00	14671.0	113.5000	13.50	31532.1	15170.0
3.25	15479.5	155.2000	13.75	31768.3	15925.0
3.50	16236.5	205.8000	14.00	32009.5	16695.0
3.75	16957.0	266.5000	14.50	32449.7	18254.0
4.00	17639.0	338.1000	15.00	32873.3	19920.0
4.25	18289.4	420.6000			

Table S10.4: Input data for Problem 10.27. All models have $X = 0.7$ and $Z = 0.01$.

M ($M_\odot$)	T_e (K)	L ($L_\odot$)	M ($M_\odot$)	T_e (K)	L ($L_\odot$)
0.70	3274.00	0.1100	4.50	18409.20	489.3
0.75	3583.50	0.1610	4.75	18989.50	593.5
0.80	3901.80	0.2290	5.00	19556.80	710.0
0.90	4550.85	0.4365	5.25	20092.30	840.3
1.00	5196.30	0.7600	5.50	20610.30	985.0
1.10	5842.30	1.2500	5.75	21058.70	1143.8
1.20	6486.30	1.9350	6.00	21546.10	1319.0
1.30	7119.90	2.8980	6.50	22444.00	1715.0
1.40	7717.70	4.1300	7.00	23267.50	2178.0
1.50	8219.00	5.6200	7.50	24062.50	2711.0
1.60	8714.00	7.5000	8.00	24819.50	3317.0
1.70	9200.50	9.8000	8.50	25539.00	3996.0
1.75	9426.30	11.1200	9.00	26213.70	4741.0
1.80	9647.10	12.5600	9.50	26847.00	5570.0
1.90	10066.10	15.8300	10.00	27439.00	6475.0
2.00	10514.80	19.8000	10.50	28037.50	7460.0
2.25	11515.00	32.5800	11.00	28631.00	8525.0
2.50	12445.50	50.2000	11.50	29141.00	9656.0
2.75	13313.20	73.9000	12.00	29640.50	10870.0
3.00	14146.50	104.7000	12.50	30149.50	12164.0
3.25	14947.10	143.9000	13.00	30663.50	13538.0
3.50	15718.50	192.0000	13.50	31104.00	14972.0
3.75	16458.50	249.5000	14.00	31578.50	16493.0
4.00	17164.60	318.0000	14.50	32014.50	18036.0
4.25	17824.00	398.0000	15.00	32423.00	19699.0