Welcome to the Astrophysical Labs for the Master of Astrophysics and Master of Physics programs Winter-Semester 2025/26

https://www.usm.lmu.de/Lehre/Lehrveranstaltungen/Praktikum/



organization of all labs: Arno Riffeser
responsible for numerical lab: Klaus Dolag
technical support: Tadziu Hoffmann
write email to (always minimum 2 of us):
arri@usm.lmu.de
dolag@usm.lmu.de
hoffmann@usm.lmu.de

Astrophysical Labs for the Master of Astrophysics and Master of Physics programs WiSe2025/26

https://www.usm.lmu.de/Lehre/Lehrveranstaltungen/Praktikum/

General information

Place and Times:

Tuesday 13:30–18:00, **University Observatory (lecture hall, ground floor)**
Briefing for the Winter Semester 2025:
Tuesday, 14th of October 2025, 13:30
*Note: Master's students in astrophysics or physics **who have already completed** their first semester of labs **do not** have to participate in this introductory briefing **if** they correctly inscribe in the LSF **confirming** that they will attend this course.*
You may ask for other students as possible partners than last semester, but there is no guarantee.
If you have e.g. Covid-19 / flu / common cold symptoms but are fit for a lab, inform your supervisor/colleagues and please ask your supervisors about the possibility to attend the lab remotely.

Date of first lab:

Tuesday, 14th of October 2025, 13:30

This lab course is for:

Master students in astrophysics and physics only.
LMU Bachelor's students in physics can be admitted **if** they are already admitted to the Master's program in astrophysics or physics **and** if we have enough tutors!
Students who **have applied** for the Master's program in astrophysics or physics but have **not been admitted cannot participate** in this lab.
In case you have questions or need further information (regarding P 2.1/2 · WP 16.1/2 · WP 17.1/2 + ...):
Please contact Arno Riffeser (arri_at_usm.lmu.de) by email.

You can take the following lab-course variants:

LSF-NR	Title			
17150	(P2)	Astrophysical (Basic) lab with exercises	9 ECTS	(Master Astrophysics)
17158	(WP16)	Instrumental lab with exercises	9 ECTS	(Master Astrophysics)
17160	(WP17)	Numerical lab with exercises	9 ECTS	(Master Astrophysics)
17145	Small astrophysical practical course		3 ECTS	(Master Physics)
17146	Large astrophysical practical course		6 ETCS	(Master Physics)

Master students of Astrophysics have to take the “basic” 9 ECTS lab, they can choose another lab in another semester.

We highly recommend to do the instrumental/observational or numerical lab in the first the semester and the basic lab in the second semester!

Master of Physics students can mix the experiments (depending on availability, no guarantee).

What you should be familiar with

The astrophysical lab deals with the following topics. If you cannot discuss these subjects to explain the basic physical concepts and their application (including the relevant equations) without looking these up, you should not take the astrophysical lab until you have brushed up on these topics.

- Parallaxes and distances.
- Magnitudes and colours.
- Doppler shift, redshift.
- Error propagation.
- Poissonian and Gaussian statistics.
- Linear regression.
- Hydrogen atom: energy levels and transition wavelengths, Lyman, Balmer, etc. series.
- Basic radiation and radiative transfer concepts: Planck function, Stefan-Boltzmann equation, opacities, emissivities, optical depth.
- Saha-Boltzmann equation.
- General scales and orders of magnitude; sizes of astrophysical objects, their masses and luminosities.

I. How the lab course is organized

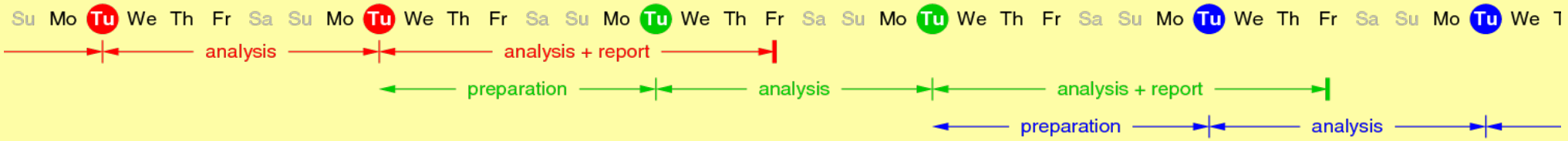
1. The course supervisor organizes the students into teams of usually two to three people for each experiment. In rare cases it may happen that a "group" consists of a single member only for various or all experiments in one semester.
2. Each team has to do six experiments (for 9 ECTS). Each experiment lasts 2 weeks.
3. The experiments take place on Tuesdays and (for 9 ECTS) (for 9 ECTS) last for 4.5 (full) hours. They are starting at 13:30 and lasting usually until 18:00.
4. In general the experiments are *assigned* to the teams, They cannot be chosen by the team members.
5. Who is doing which experiment will be announced on time on the **web pages** of the lab course.
6. **All** members of each team must be present on each of the afternoons **physically** and **mentally**.
   If you cannot attend a lab due to illness, please inform your lab supervisor in time (via e-mail or phone) and hand in a medical certificate if possible. If only *one* person from your team is ill, this does not mean that the lab will be postponed for the *other members* as well! The supervisor will make another appointment with the absent student.

   In case of absence due to illness or some other justifiable reason, the knowledge of the missing student will be evaluated at a later date and the lab will have to be performed by the student at another time (then usually alone).
7. The evaluation scheme will be explained orally during the introductory briefing and can also be found on the web pages of the lab
8. You will connect to the USM lab computers via VPN/VNC. Please install the required VNC client and the VPN client on your own computer **before** the first lab day, and verify that they work. This is mandatory!
9. You will submit your lab report via a web interface (information will be provided via email). You will not receive any credit points if your report is submitted late.

II. Lab procedure and evaluation criteria

A. The schedule is as follows:

- 1st week: oral or written examination of the required background knowledge; experimental work.
- 2nd week: further oral or written examination, finishing experimental work (if necessary); analysis of the data and discussion of the results with the supervisor.
- 3rd week : submission of the lab report to a link provided to you and starting the next experiment (Tuesday). **The deadline for the download of your lab report is Friday 18:00. You will get no credit ("failed attempt") for the lab if this deadline is not met.**
- 4th week : short feedback from your supervisor (Tue 13:10) on the lab report (no grade at that time). ("failed or not failed", plagiarism can lead to failure also at a later time).



B Each experiment must be prepared and executed by *all* participants. You need to demonstrate sufficient knowledge on each of the afternoons, otherwise this counts as a *half of failed attempt for each afternoon.*

C The lab report has to be written as described under "lab report guidelines" below.
One report per team and experiment is usually sufficient.
All group members must certify by signing the lab report that they are familiar with its contents and agree with it. In case of disagreement, any team member may hand in their own version of the lab report. In this case, submission of the lab report will be also accepted in the 4th week of an experiment (communicate it before the first deadline!).
As soon as the lab report has been submitted, it cannot be changed anymore. For reasons of equal treatment, the reports will be finally evaluated not before the end of the term.
If an essential part (including the questions and exercises) is missing, the lab report will be considered insufficient (*failed attempt*). The same is true if the report contains blatant errors in terms of understanding and results, or if the report has been copied from another group from the same or a previous semester. Illegible or sloppy reports are also considered insufficient (*failed attempt*).

The rules of referencing/citing of literature have to be followed, otherwise the lab will be also result in a "failed attempt" (no credit). If you use AI like Chat-GPT you have to add this information in your report and you have to state for which parts of the report you used it. You are fully responsible for the correctness of the content when using AI, too.

III. Guidelines for your lab report

1. Ask your lab supervisors whether they have any specific requirements for the lab report. Use the points below as a general guideline when they don't conflict with the supervisor's suggestions.
2. Don't separate your lab report into a "theory" section and a "results" section. Instead, begin with a brief motivation (about half a page) describing what can be learned from this lab and how it fits into the astrophysical context, and then immediately begin with your lab work analysis. Do not write a lengthy theory section.
3. For each step of the lab work, describe what you did in your own words, and (if applicable) what your measurement results are. Don't waste your time by copying extensively from the lab manual or writing fancy introductions. Then describe step-by-step the analysis of the data.
4. For each step in the analysis part, briefly describe what this step entails, what quantities are needed, and what assumptions are made. (In effect, discuss any theoretical considerations in individual steps at the place where they are being applied. You may refer to the lab manual if expedient.)
5. Write down each equation where it is being used for the first time, and explain what it describes and what the quantities contained therein are (unless this is already clear from the previous context). The purpose of this is a) that you become better acquainted with what the equations mean *physically* (as opposed to just how they are derived mathematically) and b) that the supervisors don't always have to skip back several pages to recall what "equation *n*" refers to.
6. Most importantly, document **all intermediate steps** with their values, so that we can give partial credit for the steps performed even if one of the values being used is wrong (perhaps as a consequence of a mistake in an earlier step). **Don't just give the final values.**

III. Guidelines for your lab report

7. Supplement each step of the analysis where expedient with graphs, tabular data, etc. if this aids in presenting the results of that step.
8. As usual, consider errors/uncertainties/confidence-ranges where applicable, make sure units are consistent, check that plots are correctly labeled, etc.
9. Interpret your results in the context of what you know about the subject.
10. End with a brief summary and conclusion (if appropriate).
11. When making plots, be sure to generate scalable graphics (PDF, Postscript, SVG) and not bitmap graphics (PNG, GIF, JPEG).
12. When citing material from the instruction manual, it is usually sufficient (ask your supervisor) to refer to this simply as “the lab manual”. *All other sources* must be cited according to established scholarly conventions.

This is just a general guideline, and each lab may of course have slightly different requirements, but the expected end result is that you demonstrate to the supervisor your grasp of the material by synthesizing the requisite aspects of the introduction and theory part of the manual together with your analysis of the data into a coherent new narrative.

III. Guidelines for your lab report

Can I use AI for writing the lab report?

Short version: ***don't.***

Slightly longer version: ***you are responsible for the content of your lab report.*** If you don't understand the subject well enough to write the lab report without the use of AI tools, it is very unlikely that you will recognize errors, inconsistencies, or other wrong claims made by these tools. (Also: any claims not directly supported by your own data or described in the lab manual must be properly cited.)

Therefore: if there is something you do not understand: 1) discuss the matter within the group, then 2) ask your lab supervisor for a meeting to discuss the subject.

To be specific and more clear: how do you fail the lab course ?

A) PLAGIARISM : If any lab report (with your name on it) copies text from elsewhere without proper referencing you fail the whole lab without a possibility to cure this.
Examples: You copy from the lab report of a previous group or a group in the same semester, you copy from a resource that you do not mention in your references (includes lab manual, literature, “Wikipedia”, “ChatGPT” etc.)

B) If more than one lab report (after the submission) is considered as insufficient (does not receive a grade of 4.0 or better) then you will fail the whole lab.
If at most one of your lab reports in this semester is considered a “failure” and if you do not do anything about it then you fail, too.
But in this case you have the chance to repeat parts of the experiments and improve on this lab report. You will receive a special date and deadline for this.
The latest date for this is the first Tuesday after you submitted the last, 6th report. If the report then still is not acceptable you fail the whole lab.

C) If your performance during ONE lab afternoons is unacceptable you get ”1/2” a failure like the yellow card in soccer. *Examples* are: no preparation, insufficient understanding of the lab material, insufficient work with the experiment itself or lacking participation in the discussion about the lab work with the supervisor and your fellow students.
If you receive at most one yellow card (1/2 failure) during the whole semester you will pass. Otherwise you fail. So insufficient performance in 2 afternoons make you fail the whole lab.

D) If you do not submit a lab report in time you will fail the whole lab. So do not submit at the last second. If a problem occurs during your submission please write to your supervisor immediately.

More about Plagiarism:

Have a look here – what is plagiarism?
https://mediatum.ub.tum.de/doc/1236069/1236069.pdf
and in particular read this part of the above text (on page 11):

"*There are different forms of plagiarism. The main types are[5].*

- ***Complete plagiarism / copy & paste plagiarism**: to use another author's text unchanged, without citation, and pretend it is one's own work (VroniPlag Wiki - Plagiatskategorien, 2014; Weber-Wulff, 2004a).*
- ***Clause splicing / Shake & paste plagiarism**: combining fragments of different texts or sentences to form a new text without citation, thus presenting it as one's own line of thought (Weber-Wulff, 2004a).*
- ***Idea plagiarism / obfuscation**: presenting another author's ideas in your own words without citing the source (VroniPlag Wiki - Plagiatskategorien, 2014).*
- ***Translation plagiarism**: Translating an original text from another language without citing the source (VroniPlag Wiki - Plagiatskategorien, 2014; Weber-Wulff, 2004a).*
- ***Bibliography balloon**: Listing references in the reference list that have not been cited in the text (Projekt Refairenz, 2017).*
- ***Bibliography amnesia**: giving in-text citations without listing the complete reference in the reference list (Projekt Refairenz, 2017).*
- ***Pawn sacrifice**: only part of the cited content is marked as a citation (VroniPlag Wiki - Plagiatskategorien, 2014).*

Note: Even if an author (e.g. a classmate) willingly consents to the uncited use of her text, you are nevertheless guilty of plagiarism, unless you cite the contribution! (Neville, 2010, p. 30)
Plagiarism arises not only through failure to cite, but also then when you do reference another's work, but do not make it clear to the reader how far the citation extends. This happens, for example, when a summary gives the impression that it is the author's own work when it is not."

Another point about text writing:

It makes no sense if you just combine literature text even if you fully follow the citation rules.

Not allowed :
Your TEXT =
"{Text of Author 1}", Citation + "{Text of Author 2}", Citation + … +

Because, if no text is from you, you can not get a (positive) credit, since one can not judge whether you can develop your own logical thoughts etc.

If you feel unsecure you can always ask your supervisor during the first and second lab day and show her/him your first text examples.

Astrophysical Lab: Winter Semester 2025 / 2026

Title of experiment:
Supervisor (1st afternoon):
Supervisor (2nd afternoon):
Group (number):
Names (of the students): (Please also indicate whether you are a Master's student in Astrophysics (MA) or in Physics (MP) and in which semester you are.)
1st afternoon (date, times of start and end):
2nd afternoon (date, times of start and end):
Time you needed to work on the report (at home) in person-hours, sum over all group members: (This information does not enter into the evaluation, but it helps us to adjust the lab content.)
Here is space for your comments: What did you like? How would you improve the labs? Would you actually like to implement these improvements yourself?
Signatures of the students, with date: With your signatures you confirm that you have not used any references for your work other than those quoted in your lab report, and that you have not copied any content from other students' reports.
Evaluation of the lab report and the performance of the students during the lab (by the supervisor): Signature of the lab supervisor, with date:

Use this cover sheet for your report:
https://www.usm.uni-muenchen.de/Lehre/Lehrveranstaltungen/Praktikum/coversheet.pdf

- 1 ECTS point corresponds to a work load of 30 hours !

- The lab is worth 9 ECTS ~1/3 of your semester work (=15 weeks)
  => it is a serious amount of work.
  (compare : a Bachelor thesis is 12 ETCS)
  = 30h/ECTS x 9ECTS / 15weeks
  = 18 h / week
  => only 4,5 h present in the lab and factor 3 at home!

Take it serious!

Feedback to students performances during the lab period and regarding their lab reports:

At the end of each lab day you can have feedback regarding your performance

- in the examination (mini-test & oral) at the beginning of each lab day
- regarding carrying out the experiment

This feedback does not imply any grades but an orientation "good/satisfying/insufficient".

After submission of your lab reports you can have an approximate feedback regarding the lab report quality (no final grade implied, just trying to spot if there is anything problematic (or very good) about a report such that you can avoid (keep) this for future reports).

Please come to see your supervisor Tuesday at **around 13:10** before starting the next lab after submission of the report or arrange another date for feedback (can be also via zoom). This takes place every 2nd Tuesday, please make an appointment with your recent supervisor! (first on 27 May, then 10 June, ...)

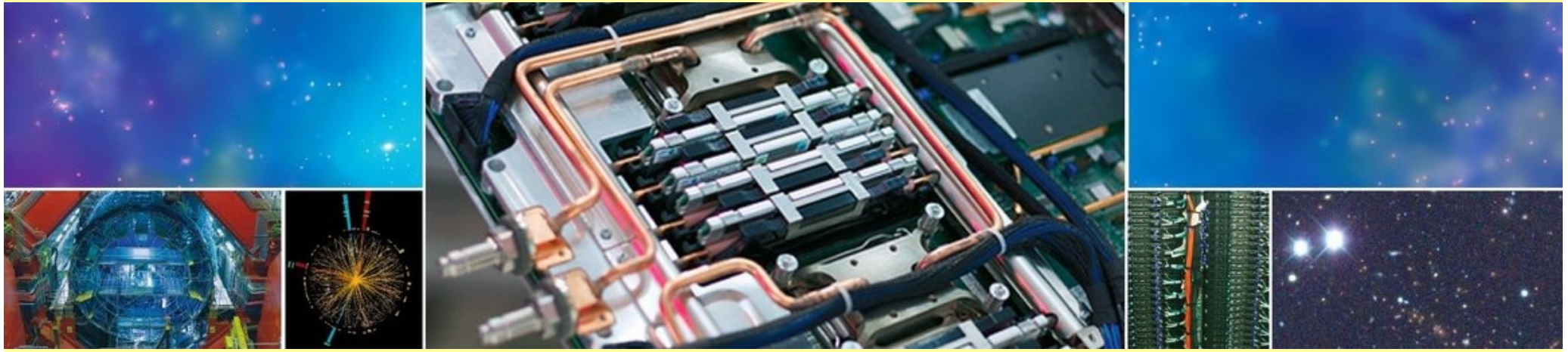
One goal is to spot insufficient lab reports in time (such that you can partly re-do one experiment / lab report). The feedback does not guarantee that you finally pass this one lab report as there could be still plagiarism found at a later time.

https://www.usm.uni-muenchen.de/Lehre/Lehrveranstaltungen/Praktikum/anleitungen.php

You deepen your knowledge about various fundamental aspects of Astrophysics and carry out a mini-project:

- **Search for extrasolar planets**, overview over all detection methods, application of the transient method
- **Spectroscopy of exoplanetary atmospheres**
- **Planetary nebulae and their central stars**: Balmer emission line spectra, forbidden lines of ONS, analyze a spectrum to get Teff of the central star.
- **Star formation**: Multi-Wavelength Studies of the Coronet Star Forming Region; empirical classification of YSOs by their SEDs in the mid (Spitzer) and near IR (2Mass), Xray emission of SF-Regions.
- **Lyman-alpha forest:** learn about the IGM using spectra of QSOs
- **Galaxy photometry**: SFB-profiles & Scaling laws for Spiral and Elliptical Galaxies
- **Galaxy evolution:** from broad band photometry of galaxies
- **Strong lensing**: Gravitational Lensing effect & Cosmology, multiple images & parametrized lens models, derive constraints for the DM-distribution in the center of the cluster Cl0024.
- **Weak lensing**: Statistical description of the Universe's matter density field & how to measure the matter density field with WL & dependency on cosmological parameters.
- **Gravitational wave follow-up**
- **Galaxy Clusters**

https://www.usm.uni-muenchen.de/Lehre/Lehrveranstaltungen/Praktikum/anleitungen.php



https://www.usm.uni-muenchen.de/~paech/Astro_Num_Lab/

WP 17.1/2 Computational methods Lab

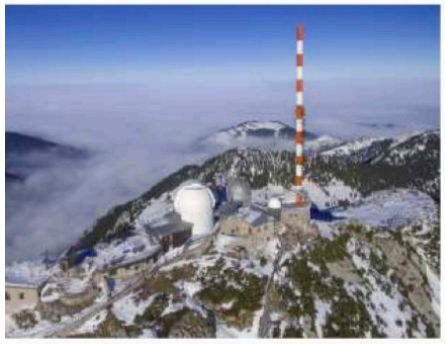
- Matrix inversion
- Integration methods
- Ordinary differential equations
- N-body simulations
- Random numbers and Monte Carlo simulation
- Monte Carlo Markov chains (MCMC)

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

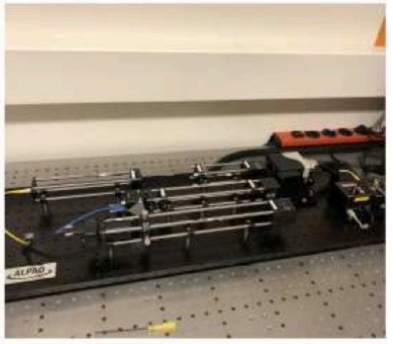
Universitäts-Sternwarte München

Fakultät für Physik der Ludwig-Maximilians-Universität

https://www.usm.uni-muenchen.de/Lehre/Lehrveranstaltungen/Praktikum/anleitungen.php







You learn about instruments, observing techniques, data reduction and analyzing own data for a science project:

- **Adaptive optics**: Atmospheric blurring, wave front sensoring, wave front correction —> improve sharpness of images from ~0.5'' to 40milli-arcsec for a 8m telescope.
- **Spatial Interferometry** from 50milli-arcsec (8m) diffraction limited resolution to milli-arcsec resolution
- **Observing with our 2.4-m radio telescope**: How does a radio telescope work? Target HI clouds in our MW, measure their spectra and determine the rotation velocity of the MW
- **Wendelstein (WST) I**: Imaging observations with our 43cm telescope on Mnt, Wendelstein, learn about CCDs and data reduction
- **Wendelstein (WST) II**: Use your data to determine the age of a globular cluster (learn about CMD of stars, isochrones, metellacity, extinction)
- **Wendelstein (WST) III**: Stellar Spectroscopy with PSPEC. How does a (fibre) spectrograph work? Observations and data reduction, wavelength calibration, stellar classification.

For the labs you will need VPN & VNC:

You can download a PDF file **VNC_for_praktikum_2025WiSe.pdf** via email

Please read it carefully, install and test it before the labs start.

THE SUCCESSFUL INSTALLATION (PRIOR TO THE LAB) IS PART OF THE FIRST EXAMINATION TAKING PLACE NEXT TUESDAY IN YOUR FIRST LAB.

YOU WILL NOT BE ALLOWED TO PARTICPATE IF THIS IS NOT SUCCESSFULLY INSTALLED ("FAILED").

If you have problems with your installations you can visit T. Hoffmann in his office, 20th Oct., 13:30-15:00

tools:

- **Google-Colab** https://colab.research.google.com
- **Overleaf** https://www.overleaf.com
- **GitHub** https://github.com
- **jupyterhub** https://jupyter.physik.uni-muenchen.de