



LUDWIG-  
MAXIMILIANS-  
UNIVERSITÄT  
MÜNCHEN

CHAIR FOR THEORETICAL SOLID STATE PHYSICS  
PHYSICS DEPARTMENT  
ARNOLD SOMMERFELD CENTER &  
CENTER FOR NANOSCIENCE



**Tensor Networks**  
**Summer Semester 2020**  
(last updated: April 19, 2020)

**Website:** [https://www.physik.uni-muenchen.de/lehre/vorlesungen/sose\\_20/tensor\\_networks\\_20/index.html](https://www.physik.uni-muenchen.de/lehre/vorlesungen/sose_20/tensor_networks_20/index.html)

**Lectures:** We 12:15-13:45, Th 14:15-15:45 (Room 450/Zoom) [First week: Tu+We]

**Tutorial:** Tu 12:15-13:45 (Room 450/Zoom) [First week: Th]

**Lecturer:** Jan von Delft <vondelft@lmu.de>

**Tutorials:** Seung-Sup Lee <S.Lee@physik.lmu.de>,  
Jheng-Wei Li <JhengWei.Li@physik.uni-muenchen.de>

**Technical advisor:** Andreas Weichselbaum

**Prerequisites:** Quantum mechanics I

**Topics:**

- Tensor Networks: Basic Concepts
- Matrix Product States (MPS)
- Symmetries
- Density-Matrix Renormalization Group (DMRG)
- Numerical Renormalization Group (NRG)
- Two-dimensional tensor networks (PEPS, TRG, TNR, MERA)
- Machine learning...

For a more detailed course plan and time table, see the course homepage, *Course Outline*.

**Lecture notes:** Will be posted well ahead of the lecture time slot.

**Tutorials:**

Will involve hands-on coding: analyzing pre-designed example codes for performing various tasks, using these to carry out standard tensor network computations. See the course homepage, *Tutorials*.

**Software:**

All codes are based on MATLAB. Every participant will need to run MATLAB scripts.

In response to the increased demand for online teaching due to covid-19, MATLAB has made free student licenses available until June 30 under the following link:

[https://www.mathworks.com/licensecenter/classroom/COVID-19\\_Access/](https://www.mathworks.com/licensecenter/classroom/COVID-19_Access/). Requirement is a MathWorks-Account (using your university email to be associated with the license).

I would not be surprised if they decide to extend the license some months beyond June 30. If they do not, you would have to download a student version (for 35 €) from here:

[https://de.mathworks.com/academia/student\\_version.html](https://de.mathworks.com/academia/student_version.html)

Save the receipt! At the end of the semester, every student that has passed the course and shows me a receipt for a MATLAB student license will be reimbursed by 35 €.

An alternative to MATLAB is Octave, <https://www.gnu.org/software/octave/>

Octave is an open-source version of MATLAB, which purportedly uses the same syntax and, in principle, should work on most of our MATLAB scripts. However, students that have tried Octave during a previous version of this course were not too happy and ended up switching to MATLAB.

**Final exam:**

Coding exercises, to be performed using the codes studied and developed during the semester.

**Literature:**

There is no suitable textbook yet for this course. For introductory topics, I will follow various review articles, and for advanced topics, the original literature. A bibtex file (to be extended and updated throughout the semester), containing bibliographic info to these articles, is available on the course homepage under *References*.

**Videos:** Lectures will be recorded and uploaded, see the course homepage, *Videos*.