

# Courses in “Advanced Quantum Technologies”

amendment to the joint curriculum between

**Kazan National Research Technical University named after A.N. Tupolev-KAI  
(Kazan, Russia) – KNRTU-KAI**

and

**Kaiserslautern University of Technology  
(Kaiserslautern, Germany) – TUK**

entered on



# 1. Preamble

This amendment specifies mutual recognition of courses and grades between participating universities. The program can be proceeded by the student in one of the two equivalent variants

Variant A — Starting at KNRTU-KAI

Variant B — Starting at TUK

1<sup>st</sup>, 2<sup>nd</sup> semesters at KNRTU-KAI,  
3<sup>rd</sup> semester at TUK  
4<sup>th</sup> semester at KNRTU-KAI or TUK.

1<sup>st</sup>, 2<sup>nd</sup> semesters at TUK,  
3<sup>rd</sup> semester at KNRTU-KAI  
4<sup>th</sup> semester at TUK or KNRTU-KAI.

The following rules apply for the Collaborative Master Program Advanced Quantum Technologies:

- Students should consider the semester plan to prepare their schedule.
- The university's administration will acknowledge courses according to section 2.
- A part of the courses at any university may be taught by a visiting professor from the other of the two universities (flying faculty).

## 1.1 Master thesis

Independent of the chosen variant, the master thesis can be prepared at either KNRTU-KAI or TUK. In any case, the master thesis must be formally registered and later defended at both institutions and comply with their formal regulations.

## 2. Course matching table

The following table matches the courses between joint curricula (semester plan) and programs of the participating institutions. The detailed description (when the name of the subjects differ) is given further in section 3.

Semester	KAI course	KAI CP	Course in Semester plan	TUK course	TUK module	TUK CP	
I	Quantum optics	3	Quantum optics	Quantum optics I	QT	4	
	Quantum electronics	5	Quantum electronics	Coherent optics	QT	4	
	Quantum mechanics (advanced course)	5	Quantum mechanics (advanced course)	Advanced quantum mechanics I	MB	4	
	Quantum information technology	5	Quantum information technology	Quantum information I	MB	4	
	Mathematical methods of computer simulations	4	Mathematical methods of computer simulations	Non-physics course from any university department I	SE	4	
	Information processing methods in photonics	3	Information processing methods in photonics	Course from any university department I	GE	3	
	Basics of research and project management	3	Basics of research and project management	Research module	RM	6	
	Quantum computing	3	Quantum computing				
	<b>Total</b>	<b>31</b>					<b>29</b>
	II	Quantum optics II	5	Quantum optics II	Quantum optics II	QT	4
Integral optics		4	Integral optics	Advanced Photonics I	QT	4	

	Femtosecond optics and single photon detectors	7	Laboratory course in quantum optics	Laboratory Course	LC	7
	Design practice	4	Research project	Research module	RM	4
	Fiber optics	3	Fiber optics	Non-physics course from any university department II	SE	4
	English	2	English	Course from any university department II	GE	3
	Optical quantum communications	4	Research project in quantum information	Research module	RM	4
	<b>Total</b>	<b>29</b>				<b>29</b>
<b>III</b>	Research project in quantum physics	8	Elective course in Many-Body Quantum Systems	Elective course in MB	MB	4
	Elective course in MB	4		Elective course in MB	MB	4
	Scientific seminar	6	Specialized Scientific Seminar	Quantum Seminar	RM	19
			Quantum Seminar	Specialized Scientific Seminar		
			Research practice	Research module		
		Research practice	12	Colloquium	Colloquium	
	<b>Total</b>	<b>30</b>				<b>31</b>
<b>IV</b>	Master thesis preparation	24	Master thesis	Master thesis	MT	30
	Master thesis presentation	6				
	<b>Total</b>	<b>30</b>				<b>30</b>

### 3. Courses and Grades

#### 3.1 Acknowledgement of courses and grades by TUK

##### 3.1.1 Preamble

The collaborative master program is formally treated as «Teilstudium» – i. e., the courses taken at Kazan National Research Technical University named after A.N. Tupolev-KAI (KNRTU-KAI) are acknowledged and in conjunction with the courses taken at Kaiserslautern University of Technology (TUK) lead to the regular Master degree of the program Advanced Quantum Physics. The rules in the governing documents of this program apply. Optional courses do not factor in the overall grade and henceforward are withdrawn from consideration.

##### 3.1.2 Equivalent Courses in the Program for 2018/2019 and following years

The following table lists the different modules of the TUK master program Advanced Quantum Physics: Quantum Technology (QT), Laboratory Course (LC), Many-Body Quantum Systems (MB), Science Elective (SE), General Elective (GE), Research Module (RM) and Master Thesis (MT). For each module, a set of TUK courses with its ECTS credit points (CP) is specified for which equivalency to one or more courses in the joint curriculum is acknowledged. This table comprises the basis for recognition of courses studied at KNRTU-KAI in the TUK master program “Advanced Quantum Physics”.

Mod.	Course title	CP	Equivalent course from the joint curriculum
QT	Quantum Optics I	4	A.1.1
	Quantum Optics II	4	A.2.1
	Coherent Optics	4	A.1.2
	Advanced Photonics I	4	A.2.2
LC	Laboratory Course	7	A.2.3
MB	Advanced Quantum Mechanics I	4	A.1.3
	Quantum Information I	4	A.1.4
	<i>Elective Courses</i>	12	A.3.1 (B.3.1 + B.3.2)
SE	<i>Elective Courses</i>	8	(A.1.5 + A.2.5)
GE	<i>Elective Courses</i>	6	(A.1.6 + A.2.6)
RM	Introduction to Working Science	26	(A.1.7 + A.1.8 + A.2.4 + A.2.7 + A.3.4), (B.2.5 + B.3.4)
	Colloquium / Theory Colloquium	1	A.3.5, (B.2.5 + B.3.4)
	Specialized Scientific Seminar	3	A.3.2, B.3.3

Quantum Seminar	3	A.3.3, B.3.3
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For the MB module, only the individual courses will be acknowledged but not the module itself. Successful completion of the module thus requires to take the module examination at TUK.

### 3.1.3 Equivalent grades

The following table defines equivalent grades that apply when graded results of courses taken at KNRTU-KAI are acknowledged by TUK.

KNRTU-KAI		TUK	
<i>score</i>	<i>designation</i>	<i>grade</i>	<i>designation</i>
0-50	failed	5,0	failed
51	satisfactory	4,0	sufficient
52-55	satisfactory	3,7	sufficient
56-60	satisfactory	3,3	satisfactory
61-65	satisfactory	3,0	satisfactory
66-70	satisfactory	2,7	satisfactory
71-75	good	2,3	good
76-80	good	2,0	good
81-85	good	1,7	good
86-92	excellent	1,3	very good
93-100	excellent	1,0	very good

## 3.2 Acknowledgement of courses and grades by KNRTU-KAI

### 3.2.1 Equivalent Courses in the Program for 2019/2020 and following years

The following table lists the compulsory (CO) and elective (EL) courses as well as the practices (PR) and the final state certification (SC) relevant in KNRTU-KAI study program. For each section, a set of KNRTU-KAI courses with its Russian credit points (CP) is specified for which equivalency to one or more courses in the joint curricula is acknowledged. This table comprises the basis for recognition of courses studied at TUK by KNRTU-KAI.

Type	Course title	CP	Equivalent course from the joint curriculum
CO	Foreign language for professional use	2	A.2.6, B.2.4
	Quantum Optics	8	(A.1.1 + A.2.1), (B2.1 + B.2.2)

	Quantum Information Technology	5	A.1.4, B.1.4
	Optical Quantum Communications	4	A.2.7, B.2.5
	Quantum Computing	3	B.2.5
	Quantum Mechanics (Advanced Course)	4	B.1.3
	Quantum Electronics	5	B.1.1
	Femtosecond Optics and Single Photon Detectors	7	A.2.3, B.1.7
	Mathematical methods of computer simulations	4	B.1.5
	Information processing methods in photonics	3	B.1.6
	Fiber Optics	3	B.2.3
	Integral Optics	4	B.1.2
	Basics of Research and Project Management	3	B.2.5
	Research Project	8	A.3.1
	Scientific Seminar	6	(A.3.2 + A.3.3), B.3.3
EL	Quantum Field Theory	4	A.3.1*, B.3.2*
	Non-stationary Statistical Mechanics	4	
	Many-particle Quantum Theory I	4	
	Solid State Physics	4	
	Quantum Gases	4	
	Computational methods of solid state theory from initial principles	4	
PR	Design Practice	4	A.2.4, B.2.5
	Research Practice	12	(A.3.4 + A.3.5), B.3.4
	Diploma Practice	24	A.4.1, B.4.1

\* the equivalent course can only be acknowledged for one of the listed KNRTU-KAI courses

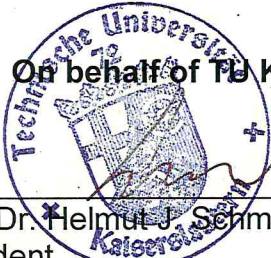
### 3.2.2 Equivalent grades

The following table defines equivalent grades that apply when graded results of courses taken at TUK are acknowledged by KNRTU-KAI.

TUK		KNRTU-KAI	
<i>grade</i>	<i>designation</i>	<i>score</i>	<i>designation</i>
5,0	failed	0-50	failed
4,0	sufficient	51	satisfactory
3,7	sufficient	52-55	satisfactory
3,3	satisfactory	56-60	satisfactory
3,0	satisfactory	61-65	satisfactory
2,7	satisfactory	66-70	satisfactory
2,3	good	71-75	good
2,0	good	76-80	good
1,7	good	81-85	good
1,3	very good	86-92	excellent
1,0	very good	93-100	excellent

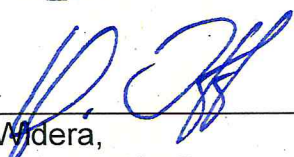
## Signatures

On behalf of TU Kaiserslautern



Prof. Dr. Helmut J. Schmidt,  
President

i.v.




Prof. Artur Widera,  
Coordinator of the MSc Program

On behalf of KNRTU-KAI



Prof. Albert Gilmutdinov,  
Rector



Prof. Sergey Moiseev,  
Coordinator of the MSc Program





DP Dammach  
~~DP~~ Kopyover  
Hedeck

1. May 14