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THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

ONE YEAR OF ICTP DIPLOMA COURSES ON-LINE USING THE AUTOMATED EyA RECORDING SYSTEM

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Abstract

The 12-month pre-Ph.D ICTP Diploma Courses in the fields of Condensed Matter Physics, High Energy Physics, Mathematics, Earth System Physics and Basics Physics have been recorded using the automated, low cost recording system called EyA developed in-house. We discuss the technical details on how these recordings were implemented, together with some web usage statistics and students feedback. As yet, no similar endeavor has been made to put on-line a complete high-level Diploma Programme, due to the high costs involved when using alternative recording solutions. These recordings are freely available on the website **www.ictp.tv**

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1. MOTIVATION

Talented young science students in developing countries are sometimes limited in achieving their full potential due to the absence of advanced training at a postgraduate level, according to standard international criteria. With the aim of filling this gap, the Abdus Salam International Centre for Theoretical Physics (ICTP) in Italy [1] has instituted, since 1991, an intense 12-month programme in the fields of Condensed Matter Physics, High Energy Physics, Mathematics, Earth System Physics and, most recently, Basics Physics [2]. The programme focuses mainly on young participants from developing countries where high-quality advanced scientific training is less accessible.

Due to some obvious logistical constraints, and to the high costs involved, the number of selected students to be present on campus is limited to around 10 scholarships in each of the 5 Diploma fields. To fully support 50 students from developing countries is a big effort, and this amount can be increased further by offering a new opportunity to unselected applicants a *"virtual presence"* to the Diploma Lectures

New prototype services directed to the on-line scientific community are being investigated at ICTP by means of its recently created Science Dissemination Unit (SDU) [3] which aims to bridge the knowledge divide. These prototype services include synchronized multimedia presentations of some public lectures and seminars, as well as the automated recordings of the ICTP Diploma Course lectures. One example of such research is the automated recording system named "*Enhance your Audience*" (EyA) [4-6], which is an innovative rich-media system developed to archive scientific lectures carried out using traditional blackboard lectures, which has also been proven to be useful for modern (PPT, PDF, *etc.*) presentations. EyA is a completely automated, non-intrusive and low cost system, which allows the recording of any scientific lecture without dedicated human intervention for post-processing or capturing. Lecturers are not required to follow any special technical constraints like pressing buttons or wearing a microphone, *etc*. It aims to widen the audience of educational activities at no extra cost and to offer a high quality e-learning experience.

In the following, details about the ICTP Diploma Course automatic recordings using the EyA system are given together with some web usage statistics and system assessment. So far, no similar worldwide endeavor has been made to put on-line a complete pre-PhD Diploma Programme due to the high costs involved when using alternative recording solutions (as, for instance, those employed in the MIT Open Courseware (OCW) [7]). The complete ICTP Diploma Programme recordings for the whole year: September 2007 - August 2008, plus the current academic year, are freely available at the website **www.ictp.tv**

ICTP publishes these lectures on the web and distributes them in digital form only for educational purposes. It does not endorse or sponsor any commercial product, service or activity, and does not permit the recorded material to be used for commercial purposes.

2. TRADITIONAL LECTURING AND SCIENTIFIC PRESENTATIONS

The ICTP is an international institution where scientific strengths are combined with a strong dissemination effort [1]. The main challenge is to nurture scientific talent within and from developing countries. Most of its Diploma Courses' lectures are carried out on campus in standard classrooms with a traditional blackboard plus a video projector connected to a PC. On the other hand, typical scientific presentations, including seminars, talks, lectures, *etc.*, are much more complex in form than the relatively simpler PowerPoint (PPT) or Keynote presentations. In fact, they can include the simultaneous use of a blackboard, transparencies and overhead projector, the display of simulations via animations, the use of a laser pointer, the display of films and photos from experiments, devices, *etc*. So all of these variables need to be considered and synchronized when producing and archiving a recording in order not to lose information.

To share an idea, or give a scientific lesson, the medium used for writing has major implications in terms of content and style of presentation. For example, in our days, a lecturer can write on an electronic board, seamlessly integrating pictures and interactive programs from the web. Both of these can be loaded directly from a hard disk or the Internet. Projects such as e-Chalk [8] also includes algebraic formula manipulation via handwriting recognition, *etc*. [9,10].

To produce rich-media presentations and videos for Internet streaming (live or off-line) both audience and available computer/networking facilities need to be considered. It is necessary to select low-bandwidth compliant applications that also keep the video quality as high as possible, and to follow as much as possible the proposed open standards for the authoring of presentations to make them visible under many platforms and operating systems. To automate as much as possible the production of the presentations it is also important to reduce any post-processing and editing work in terms of human resources and financial costs.

One possibility to achieve these goals is given by our EyA prototype for an automated recording system as used at the ICTP Diploma Course [2]. EyA is an innovative system developed to archive and share physics and mathematics lectures carried out using either modern (PPT, PDF, etc.) presentations or the old and traditional blackboard. Most important though, lecturers are not required to follow any special technical constraints. The final result looks similar (or as close as) to a high quality learning experience for the remote audience.

3. EyA at WORK

The design of the EyA system is shown schematically in Figure 1.

- Video and audio is recorded on the local computer *("producer"*) with a webcam and USB microphone fixed on the wall. Photos are taken every few seconds with a digital camera controlled by USB and proprietary software (shooting time of photos is available in their EXIF data field) and immediately downloaded from the camera to the computer via USB (fast even for high resolution images). The recording time is set in slots of one hour to follow usual classroom schedules. Continuous hourly recordings are carried out during the day. In Figure 2 an example of EyA Box is shown with hardware details.

- All photos, together with the video and the information therein contained about the synchronization, are transferred through the network to a dedicated server (*"master"*) as a TAR archive. This is done immediately after every hour of recording, and may happen at the same time while the computer is recording the next hour.

- The *"master"* server expands the TAR files received from multiple rooms (which have unique names, with *'time stamps'* and information about the rooms), and queues them for post-processing. They are immediately processed room-by-room, creating a QuickTime (QT) synchronization track that, added to the video file, provides the synchronization between the images and the movie. High quality **images are also compared together to drop duplicates** (*i.e.*, images that do not change respect to the previous ones above a threshold), in order to decrease the space needed for the storage and the fast download of recordings. At the end of the process, all images, thumbnails, video file and synchronization track are combined together to build a web page, showing the video and the images, with a zoom facility that allows the reading of tiny details (such as a simply, tiny dot, indicating a mathematical derivative!). The final result is then compressed into a zip file (with average dimension of about 170MB per recorded hour) and transferred to a public web server.

- The web server publishes automatically the recording with all relevant information (room, starting and ending time, size of the zip file). This is done within 10 minutes after the conclusion of the recorded hour (in case of multiple rooms processed by the same *"master"* server, this may take a longer time, like five minutes more for every room after finishing a previous process). In Figure 3 a screenshot of the web-based presentation with audio, video and synchronized photos of the blackboard is shown with the possibility of zooming up areas of the blackboard at high resolution. The synchronized video presentation can be selected in either QuickTime or Flash formats.

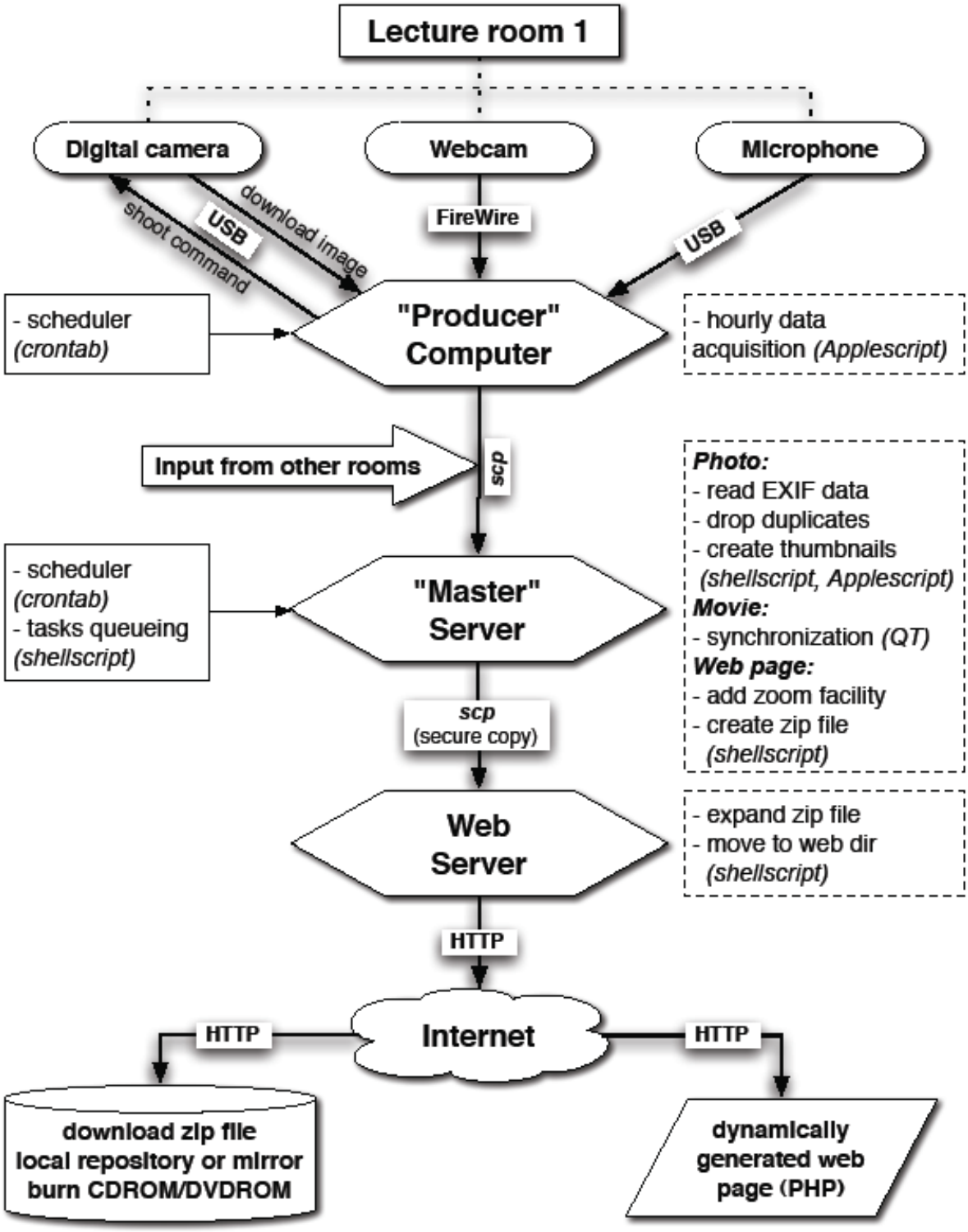

Figure 1: The EyA framework. A redundant unit is equivalent
to add an extra ‘ input from other rooms’ in the same Lecture room 1.

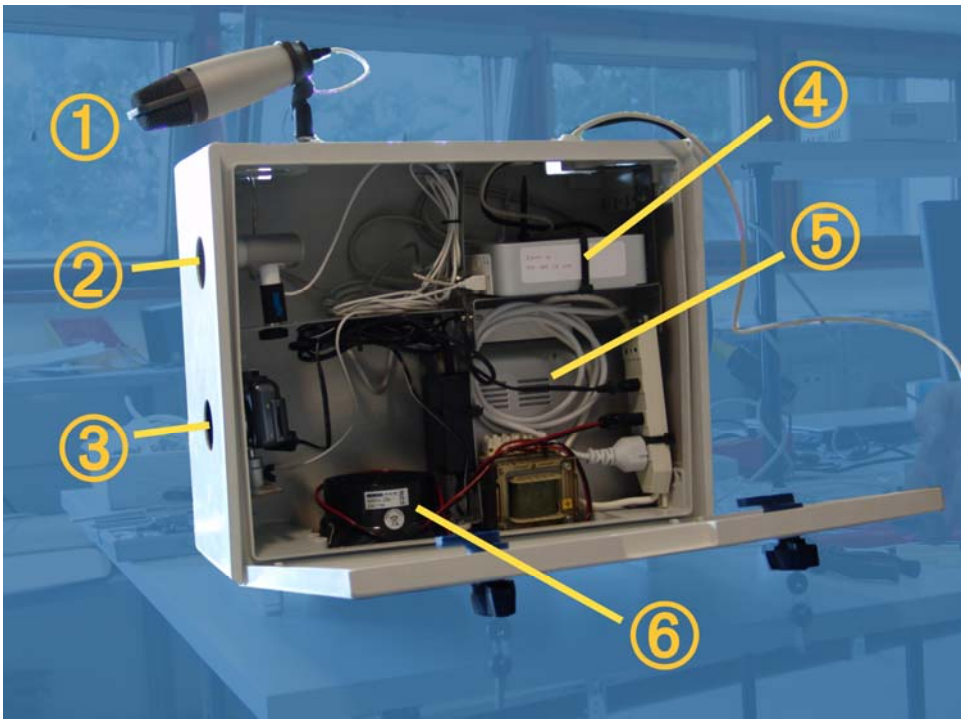

Figure 2: Example of EyA Box: (1) USB extensible microphone (which may also be fixed on a wall), (2) Firewire webcam, (3) digital camera 7 (or higher) Mega Pixels, (4) MiniMac computer, (5) UPS and (6) fan.

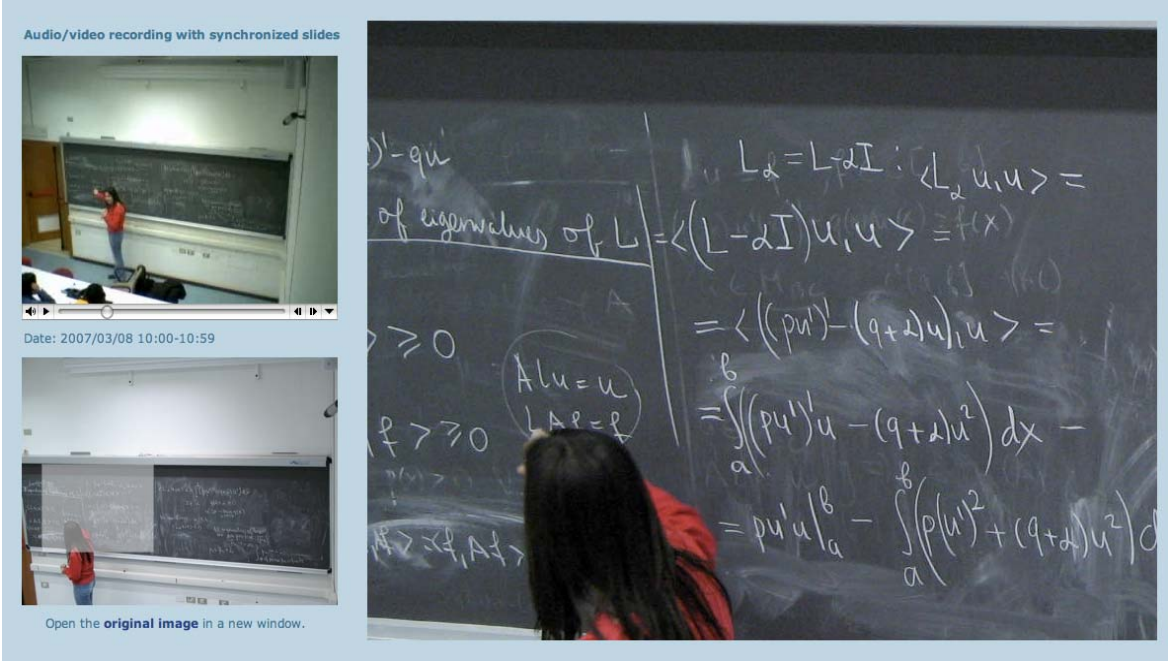

Figure 3: Example of EyA of a traditional lecture with slides, blackboard, audio plus video (on top left) recorded and synchronized automatically. The arrow opens (OnMouseOver) a high resolution zomed image (on the right) where even a dot can be distinguished.

To deploy a (redundant) EyA recording set, knowledge of the Macintosh Operating System is required. As of December 2008, a rough estimation of overall costs is less than 2,500 Euro for each

room being recorded including a redundant system of 2 computers miniMac *"producers"*, 2 digital cameras, 2 webcams, 2 microphones, 1 UPS, some proprietary software licenses for QuickTime Pro video and to zoom the blackboard images, cables, accessories, mounting, safe plastic enclosure with lockers, *etc.*. The implementation of two independent EyA units per room with two different audio, video and slides inputs allow to obtain more than 99% of reliability for the recordings. In case of the failure of one EyA unit, the redundant unit is used as a backup. Everything is integrated in just one case box. Another 500 euro are needed for the dedicated (fast) "*master"* server used to process the recordings (from 1 up to 4-5 rooms), with external hard disks for extra backup. Additional hardware include: *i)* a webserver for publishing the recorded material, also with large storage space (with a cost of about 1,000 euro including Terabytes of external space disk); *ii)* an Ethernet fast wireless network to connect all computers together and *iii)* a machine for burning CD/DVD ROM if needed. Because of these figures, EyA can be considered as a relatively low cost system compared to available alternatives [7]. In our experience, this investment is promptly recovered by the increase of visibility and interest in our workshops, conferences activities, Diploma courses, *etc*. by a large audience connected to the Internet across the world.

4. SCIENTIFIC e-CONTENTS and ASSESSMENT

Lectures given within the ICTP Diploma Course for the whole academic year starting September 2007 to August 2008 and the current one have been automatically recorded using the new automated EyA system. The access to this digital material is made available on the website: **www.ictp.tv** for free. The project aims to enhance ICTP's mandate of transferring knowledge to scientists from developing countries. We also hope that these public recordings are useful for lecturers beginning their teaching careers in science around the world.

For the academic year 2007-08, there were more than 2,265 hours of available recorded lectures delivered in 3 different rooms. These are distributed as listed in the Appendix and divided into 54 different courses. Since 8 *"producer"* computers were used in all with a total cost of < 5000 Euro, we estimate that the cost for each recorded hour is less than 2 Euros. This figure is 100 times less expensive than the costs induced when using other systems [7]. Altogether, the disk space used to store this huge digital content amounts to about 1 Terabyte.

Due to some technical reasons like long power cuts, system miss-configuration, camera problems, *etc.* 19 hours were not recorded during the academic year 2007-2008. This means that only less than 0.8% of lectures were not recorded. More than 60 Lecturers and Tutors participated in these recordings. The Diploma courses of Mathematics and Basic Physics delivered the largest number of hours of lectures during the year (580 recording hours). The longest course was given in Basic Physics in the field of

Quantum Mechanics (110 recording hours). Some web statistics on this Diploma recordings usage is as follows.

- **Monthly unique visits** (excluding locals from ICTP):

Nov07	*Dec07*	*Jan08*	*Feb08*	*Mar08*	*Apr08*	*May08*	*Jun08*	*Jul08*
168	**591**	**597**	**1516**	**1034**	**1013**	**942**	**1436**	**1304**

- **Bandwidth usage** (GBytes)

Nov07	*Dec07*	*Jan08*	*Feb08*	*Mar08*	*Apr08*	*May08*	*Jun08*	*Jul08*
117.28	**708.83**	**210.52**	**564.33**	**437.41**	**477.42**	**467.72**	**604.92**	**475.07**

- ***Recording hours downloaded per Month***
  (1 recording hour is less than 200 Mbytes average)

Nov07	*Dec07*	*Jan08*	*Feb08*	*Mar08*	*Apr08*	*May08*	*Jun08*	*Jul08*
586	**3544**	**1052**	**2821**	**2187**	**2387**	**2338**	**3024**	**2375**

- ***Average Recording hours downloaded per Day***

Nov07	*Dec07*	*Jan08*	*Feb08*	*Mar08*	*Apr08*	*May08*	*Jun08*	*Jul08*
19	**118**	**35**	**94**	**72**	**80**	**78**	**100**	**79**

Figure 4: ICTP Diploma students at work following the daily on-line recordings.

A benchmarking questionnaire was proposed to 52 students (some shown in Figure 4) at the end of the first semester in order to have their feedback and evaluate the usage and utility of the recordings. It was found that the time spent reviewing the recordings were approximately 10 hours/week (equivalent to the number of lectures hours given within each Diploma field). About 20% of the students advertised the on-line recordings to colleagues in their own countries. Half of the students followed

on-line courses not belonging to their main field of study (something not possible without having such recordings available on the web). In fact, the availability of on-line recordings changed the learning methods for 97% of students interviewed. From the students comments we realized that the on-line recordings have been mainly useful for the following:

- to review/revise missing points and concepts,
- to clarify handwritten notes,
- to recover missed classes,
- to understand concepts when lecturers were going too fast,
- to prepare for exams,
- to adapt to the English environment,
- to avoid writing notes and concentrate on the blackboard,
- to mark it for possible long-term research.

5. FINAL REMARKS

If a Lecturer is adept at blackboard work, students may get more from this traditional method than from media sessions which lack of continuity since once a PPT slide is advanced, it is gone[11]. Using the automated, non-intrusive, low cost EyA recording system, blackboard notes and/or projected slides are automatically grabbed and synchronized with the audio-video without human intervention. Besides, EyA recordings offer the benefit of seeing the accompanying physical gestures, body language and the like which are inherent in the pedagogical process [12]. Such lecture recordings can also serve as a main content source in a number of didactic scenarios [13].

The automated EyA system is a prototype directed to the world-wide scientific community [14] and has been implemented using *state-of-the-art*, low-cost technologies keeping in mind both the scientific audience and the available computer/network facilities in developing countries. The poor connection to international lines in some cases is not considered as an obstacle for modernization, since the delivery of hard disks or DVDs with the recorded EyA lectures reproducing the creative environment of classrooms is now a reality.

The issue of an institutional policy that considers the copyright and commitment to authorize all activities publicly on the Internet for educational purposes is very important and needs to be considered in future applications of EyA beyond ICTP.

Other potential applications of EyA need to be explored [15]. These include, for example, use of the recorded scientific lectures within an e-learning content management system and the vision of a complete recorded conference in a remote University. Another possibility is to install Totems around

campuses to allow the burning of CD/DVD ROOMs with the recordings. EyA aims to multiply and enhance learning audiences at no extra costs for a traditional scholarly activity. A Linux version of EyA, called openEyA [16], is under development.

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APPENDIX: 2007-2008 Recorded Courses Timeline

- **Condensed Matter Physics** (CM: recorded hours: **352 hrs** / missing hours: 2)

  Mathematical Techniques, *Symmetries, Electron Bands and Phonons*, *Advanced Quantum Mechanics, Statistical Mechanics*, *Many-Body Physics*, *Advanced Statistical Mechanics*, *Biological Physics, Superconductivity and Semiconductors.*

- **High Energy Physics** (HE: recorded hours: **390 hrs**)

  Quantum Electrodynamics, *Relativistic Quantum Mechanics*, *Lie Groups and Lie Algebras*, *Introduction to Particle Physics*, *General Relativity*, *Quantum Field Theory* and *Susy Field Theory*.

- **Mathematics** (MTH: recorded hours: **588 hrs** / missing hours: 4)

  Linear Algebra, *Foundations of Mathematical Analysis*, *Introduction to Ordinary Differential Equations*, *Calculus on Rn*, *Complex Analysis*, *Topology, Ordinary Differential Equations, Abstract Algebra*, *Real Analysis*, *Algebraic Topology*, *Differential Geometry*, *Real Analysis II*, *One Dimensional Dynamics*, *Functional Analysis, Functional Analysis II*, *Partial Differential Equations* and *Algebraic Geometry*.

- **Earth System Physics** (ESP: recorded hours: **356 hrs**)

  Wave Physics, *Introduction to the Physics of the Earth System*, *Mathematical Methods in Geophysics*, *Environmental Data Analysis*, *Physics of the Oceans*, *Mechanics of Earthquakes and Tectonophysics*, *Physics of the Atmosphere*, *Seismology, Advanced Topics, Inverse Modeling*, *Earthquake Prediction*, *Nonlinear Dynamics* and *Numerical Modeling of the Atmosphere*.

- **Basics Physics** (BP: recorded hours: **579 hrs** / missing hours: 9)

  Mathematical Methods, *Classical Mechanics*, *Quantum Mechanics, Advanced Electromagnetism, Advanced Quantum Mechanics*, *Solid State Physics, Statistical Mechanics and Relativistic Quantum Mechanics.*

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