AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: CP Violation in Heavy Flavour Physics

Academic year: 2017/2018 Code: JFT-2-040-s ECTS credits: 3

Faculty of: Physics and Applied Computer Science

Field of study: Technical Physics Specialty: —

Study level: Second-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 0

Course homepage: http://home.agh.edu.pl/~amucha/CPV.php

Responsible teacher: dr inż. Obłąkowska-Mucha Agnieszka (amucha@agh.edu.pl)

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Module summary

Solutions af the Dirac equations, weak lagrangian and effects of CP violation in b and c hadron decays are introduced on this course. Experimental discoveries are discussed.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence			
M_K001	Students works in teams in order to work out of the solutions to given problems.	FT2A_K01, FT2A_K01	Activity during classes
M_K002	Stuents are familiar with a scientific artice and are able to discuss and prepare presentations about their main issues.	FT2A_K01, FT2A_K01	Activity during classes
M_K003	Student can analyse data and present the results	FT2A_U05, FT2A_W05, FT2A_W05, FT2A_U05	Activity during classes
Skills			
M_U002	Student is able to solve the eigenvalue problem.	FT2A_U01, FT2A_U01, FT2A_U03, FT2A_U03	Execution of exercises
M_U004	Students prepare a project that shows the phenomenon of mixing in neutral meson system	FT2A_U05, FT2A_U05	Project
Knowledge			

M_W001	Student has the knowledge about fundamantal particles and interactions.	FT2A_W05, FT2A_W05	Activity during classes
M_W002	Student knows the importance of heavy flavour quarks in the Standard Model	FT2A_W01, FT2A_W01, FT2A_W05, FT2A_W05	Activity during classes
M_W003	Student knows and is able to solve the Schrodinger equation	FT2A_W01, FT2A_W01, FT2A_W05, FT2A_W05	Oral answer

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Others	E-learning
Social competence												
M_K001	Students works in teams in order to work out of the solutions to given problems.	-	+	-	+	-	-	-	-	-	-	-
M_K002	Stuents are familiar with a scientific artice and are able to discuss and prepare presentations about their main issues.	-	-	-	+	-	-	-	-	-	-	-
M_K003	Student can analyse data and present the results	-	-	-	-	-	-	-	-	-	-	-
Skills												
M_U002	Student is able to solve the eigenvalue problem.	+	+	-	+	-	-	-	-	-	-	-
M_U004	Students prepare a project that shows the phenomenon of mixing in neutral meson system	-	-	-	+	-	-	-	-	-	-	-
Knowledge												
M_W001	Student has the knowledge about fundamantal particles and interactions.	+	-	-	-	-	-	-	-	-	-	-
M_W002	Student knows the importance of heavy flavour quarks in the Standard Model	+	-	-	-	-	-	-	-	-	-	-
M_W003	Student knows and is able to solve the Schrodinger equation	+	+	-	+	-	-	-	-	-	-	-

Module content

Lectures

Discrete symmetries in the Standard Model (2h).
Matter and antimatter. Symmetries and conservation laws. Discrete symmetries P, C, T. Discussion on solutions of Schrodinger and Dirac equations.

CP Symmetry in neutral meson system (2h).
The eigenstate of strong and weak Hamiltonian. Flavour oscillation in neutral meson system.

CP Violation in neutral meson system (4h).
Effective Hamiltonian. Eigenstates of the effective Hamiltonian. Time evolution of the neutral strange and beauty weak states.

Three types of CP Violation (2h).
CP violation in decay (direct CP Violation).
CP violation in mixing (indirect CP Violation).
CP violation in interference between mixing and decay

CKM matrix (4h).
The description of currents and amplitudes with Feynman diagrams. Cabbibo mixing matrix. Cabbibo angle.
Cabbibo-Cobayashi-Maskava (CKM) matrix. Description of CP violation in the frame of the Standard Model. The unitarity triangle.

Experimental results with CP Violation (2h).
Past, present and future of heavy quarks experiments – B-factories. LHCb.

Auditorium classes

CP symmetries and conservation laws in kaon system (1h).
Finding the rules if a given decay might occur.

Solving the eigenvalue problem (3h).
Solving the eigenvalue problem of two component system of neutral mesons with effective Hamiltonian. Time evolution of the solutions.

The angles of the Unitarity Triangle (UT) (2h).
Finding the decays and method to determine the beta and gamma angle of UT. Derivation of the equations that shows the sensitivity of these methods.

Project classes

Paper reading club. (2h)
Students choose a scientific article from a provided list and prepare presentation on that subject. Discussion.

Simulation of the flavour mixing phenomena in the neutral meson system (4h).
Basing on the equation of time evolution in the neutral meson system students prepare a simulation of this effect. They vary the oscillation parameters value and discuss the results.

Method of calculating the final grade

The final mark (FM) A – activity, T – tutorial classes, P – project
FM = 0,4 x T + 0,4 x P + 0,2 x A
Student has three attempts to get the positive mark.

In case of absence, students should contact the lecturer to become familiar with the missing classes. Within the next week, student should solve and show the problems discussed during his or her absence.

Prerequisites and additional requirements

Any course of particle physics that is certified.
Math and physics courses at the university level.
Basic knowledge of programming.

Recommended literature and teaching resources

M.Thomson “Modern Particle Physics”
A.Bettini “Introduction to Elementary Particle Physics”
D.H. Perkins “Introduction to High Energy Physics”
A.J. Buras “CP Violation in B and K decays” hep-ph/0307203
B. Kayser “CP Violation in the K and B systems” hep-ph/9702264
J. Rosner “CP Violation in B decays” hep-ph/0011355

Scientific publications of module course instructors related to the topic of the module

A. Oblakowska-Mucha et al. (LHCb Collaboration) Measurement of CP violation and B0s meson decay width difference with B0s→J/ψK+K- and B0s→J/ψπ+π- decays. Phys. Rev. D 87 (2013) 112010, 1-21
A. Oblakowska-Mucha et al. (LHCb Collaboration) Measurement of CP violation and constraints on the CKM angle γ in B± → D+K± with D → K0sπ+π- decays. Nucl. Phys. B888 (2014) 169-193
A. Oblakowska-Mucha et al. (LHCb Collaboration) Measurement of the time-dependent CP asymmetries in B0s→J/ψ K0s. JHEP 6 (2015) 131, 1-22
A. Oblakowska-Mucha et al. (LHCb Collaboration) Measurement of the difference of time-integrated CP asymmetries in D0→K-K+ and D0→π-π+ decays. Phys. Rev. Lett. 116 (2016) 191601, 1-10,
A. Oblakowska-Mucha et al. (LHCb Collaboration) Model-independent measurement of the CKM angle γ using B0→DK• 0 decays with D→K0sπ+π- and K0sK+. JHEP06 (2016) 131, 1-31
A. Oblakowska-Mucha et al. (LHCb Collaboration)Measurement of CP observables in B±→DK± and B±→Dπ± with two- and four-body D decays. Phys. Lett. B760 (2016)117-131
A. Oblakowska-Mucha et al. (LHCb Collaboration) Constraints on the unitarity triangle angle γ from Dalitz plot analysis obf B0→DK+π- decays.Phys. Rev. D93 (2016) 112018, 1-19
A. Oblakowska-Mucha (on behalf of LHCb Collaboration) Selected CPV Results from LHCb Run 1 and Prospects for CKM γ Angle Measurements in Run 2. Acta. Phys. Pol. B47 (2016) 6, 1553-1562

Additional information

None

Student workload (ECTS credits balance)

Student activity form	Student workload
Participation in lectures	16 h
Participation in auditorium classes	6 h
Participation in project classes	6 h
Preparation for classes	15 h
Preparation of a report, presentation, written work, etc.	10 h
Realization of independently performed tasks	10 h
Completion of a project	20 h
Contact hours	5 h
Summary student workload	88 h
Module ECTS credits	3 ECTS