Skoltech
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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Stepan Baryshev

PhD Program: Physics

Title of Thesis: Photon correlations of optically trapped polariton condensate

Supervisor: Professor Pavlos Lagoudakis
Co-supervisor: Dr. Anton Zasedatelev

Name of the Reviewer: Daniele Sanvitto

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 30-09-2022**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The thesis by Mr. Stepan Baryshev entitled “Photon correlations of optically trapped polariton condesate” presents two different subjects, a first part dedicated to the optical properties of polyyne carbon chains confined between gold nanoparticles and a longer second part in which a thorough study on the correlation properties of a trapped polariton condensate is described.

After a brief overview the thesis starts in chapter 2 with the study of the polyyne carbon chains for which the candidate has observed, via TRSPC, the photoluminescence decay of several excitonic species. The radiative and non-radiative decay are identified via time resolved PL. This part is quite short and clearly not the main core of this thesis. Yet the description of the dynamics of the excited carriers are well understood and backed up by a theoretical analysis–although this is only present in some of the publications of the candidate but missing in this thesis.

The rest of the dissertation is dedicated to the study of correlations in a confined condensate of microcavity polaritons. This is clearly the main topic of this work, given the substantial richness of details about the experiments performed and their interpretation. After an introduction in chapter 3 on the subject of exciton-polaritons, followed by a description of the sample and the experimental setup used for studying polarisation resolved PL and to perform correlation measurements, data are described in chapter 4 and 5. Chapter 4 concerns with a series of correlation measurements, $g^{(2)}$, on different polarisation basis which evidence the role played by an in-plane and out-of-plane effective magnetic field on the dynamics of the $g^{(2)}(\tau)$. These fields arise due to the presence of a fine structure splitting of the polariton state cause by sample birefringence and spin dependent interactions. Finally, the effect of the trap anisotropy on the correlation measurements is also described for a sample spot where the position-dependent birefringence is minimised. The last chapter describes a study of the Hong-Ou-Mandel effect applied to a coherent, rather than quantum, state of polaritons. It is observed that the HOM on a polariton condensate gives a visibility dip which is, though, 3 times less deep than what expected for a laser. The explanation given is a mismatch of the modal profile due to a random spatial mode fluctuation of the condensate. The same effect is tested against the trap dimension and polarisation ellipticity of the pump.

I appreciated this thesis which is a nice thorough study of the emission characteristics of a polariton condensate, using a technique which is quite unusual and at the same time giving interesting results. The methodology used is sound and well described even for those experiments that are less “orthodox”. The thesis is well organised with a consequential flow in the narrative except, forcedly, for the first chapter which describes a different topic. The grammar though should be improved. Sometimes the reader can incur in simple oversights but there are also many phrases which are ill-formed or with genuine mistakes. I suggest that the candidate in this month before the viva would carefully revise his thesis, I am sure that with proper care many of these errors could be corrected.

This thesis work has generated several publications of which at least two of high impact, a nano letters and a physical review letter. In the latter Mr. Baryshev is also the main author of the work described. I did not find the last chapter in any publication, however it is possibly in preparation.

In addition to a complete careful reading of the thesis to improve it from a grammatical point of view I also suggest checking the consistency of the phrases and figures. For instance, references to figures 4-34-4 and 4-54-6 in chapter 4 or the labels which sometimes are too small, like those at the end of chapter 5. Also it would be nice if some concepts like “the condition of tilted limit cycle regime” would be explained rather than given for granted.

Provisional Recommendation
☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*
☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*
☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*