


## Rapport d'évaluation du mémoire de thèse / Evaluation report of the PhD thesis

<b>Doctorant</b>	Nom prénom / Full name	LAFUENTE-SAMPIETRO Alban
<b>PhD student</b>	Ecole Doctorale / Doctoral School	Physique
	Titre thèse / PhD Title	Contrôle optique du spin d'un atome magnétique dans un semiconducteur : spin hybride trou-Manganèse et Chrome
<b>Rapporteur</b>	Nom prénom / Full name	CHAMARRO Maria
<b>Reviewer</b>	Etablissement / Institution	Université Pierre et Marie Curie
	Statut, fonction / Status, position	Professeur

### Qualité du mémoire, rédaction & illustrations / Thesis quality, style & illustrations


 Satisfaisant / Satisfactory [ ]      Bon / Good [ ]      Très bon / Very good [ ]      Exceptionnel [x]

#### Commentaires/comments :

[The thesis manuscript is of excellent quality. It is written in English according to the following scheme: an introduction, five chapters, and conclusion including perspectives. An effort of pedagogy is obvious and very appreciated by the reader, in particular, when Alban LAFUENTE-SAMPIETRO describes the basic concepts necessary for the comprehension of the studied physical phenomena. The choice of figures is relevant and the list of references is adequate. ]

### Contexte, état de l'art, collaborations / Background, state of the art, collaborations :

#### Commentaires/comments :

[Alban LAFUENTE\_SAMPIETRO has dedicated his thesis work to the study of the optical control of the spin of a magnetic atom in a quantum dot. This work is part of highly competitive and highly topical research activity on the quantum information processing. In this framework, the possibility to control individual spins in semiconductors nanostructures is an important step for any spin-based solid-state quantum computing devices. The group of Lucien Besombes at Institut Louis Neel have made, in these sense, an original choice of system: the localized spin of an individual magnetic atom (Mn or Cr) incorporated to a II-VI quantum dot. Such individual spin presents many interesting properties as spin qubit: stability, reproducible quantum properties and long spin coherence times at low temperatures. Furthermore, semiconductor quantum dots allow efficient electrical or optical manipulation for individual carriers as well as scalability. Thanks to the strong exchange interaction between the carriers and the magnetic atom spins, the spin of a magnetic atom in a quantum dot can be initialized by the injection of spin polarized carriers and read-out by analysing the polarization of emitting photons.

Experimental work like the one conducted in this thesis requires state-of-the-art samples. Growth of the Mn-doped quantum dots was carried out in Grenoble INAC CNRS by Hervé Boukari and the Cr-doped quantum dots were grown in Tsukuba, in the team of Pr. S. Kuroda. The Ph-D work has been accomplished under a joined co-supervision between University of Grenoble Alpes and the University of Tsukuba. ]

### Qualité scientifique, méthodologie, expérimentations, validation Scientific quality, methodology, experiments, validation



Satisfaisant / Satisfactory [ ]

Bon / Good [ ]

Très bon / Very good [ ]

Exceptionnel [x]

*Commentaires/comments :*

[In chapter III, Alban LAFUENTE-SAMPIETRO discuss the the electronic structure and dynamics of a Mn spin coupled to a single hole in a positively charged CdTe/ZnTe quantum dot. He identifies different  $\Lambda$ -level systems formed by two hole-Mn ground states connected to one electron-Mn excited state via two transitions of opposite polarizations and studies the dynamics of the hole-Mn hibrid spin by using the resonant photoluminescence of the excited state. Alban LAFUENTE-SAMPIETRO shows experimentally that an efficient spin relaxation channel in the nanosecond time scale is present for hole-Mn hibrid spin in the studied samples and confirms, by modelling, that hole-Mn flip-flops are driven by an interplay of Mn-hole exchange interaction and the lattice deformation of acoustic phonos. Leaks out of  $\Lambda$ -level systems are also discussed and studied by autocorrelation of the resonant photoluminescence without or with an applied transverse magnetic field.

Finally in chapter III, Alban LAFUENTE-SAMPIETRO demonstrates the coherent transfer of population between electron-Mn spin states and shows that it is directly related to the anisotropic strain in the plane of quantum dots and can be tuned by an applied magnetic field.

Chapters IV and V constitue the more original personal contribution of Alban LAFUENTE-SAMPIETRO because they contain the physics of a new spin qubit system developped during PhD work : a single Cr atom inserted in a CdTe/ZnTe quantum dot. In chapter II, Alban LAFUENTE-SAMPIETRO demonstrates the incorporation of a single Cr atoms in CdTe/ZnTe self assembled quantum dots and discribes the by molecular beam epitaxy growth on ZnTe substates.

Alban LAFUENTE-SAMPIETRO, in chapter IV, summarizes studies of magneto-optic spectroscopy of the Cr spin electronic structure. A large magnetic anisotropy induced by biaxial strain in the plane of the quantum dots and an antiferromagnetic coupling of hole-Cr coupling are evidenced. He finally demonstrate the optical initialization and read-out of the spin of an individual Cr atom inserted in a II-VI quantum dot.

In chapitre V, Alban LAFUENTE-SAMPIETRO discuss the results on dynamics of Cr spin under continuous optical excitation obtained by using photon correlations techniques. He measures a spin fluctation time of the order of 10ns which depends on excitation power and concludes that this spin dynamics is dominated by carrier-Cr coupling. Alban LAFUENTE-SAMPIETRO also discuss the spin relaxation in absecne of opitcal injection of carriers, this spin relaxation is controlled by the spin-lattice interaction and is found in the order of  $\mu$ . Finally, Alban LAFUENTE-SAMPIETRO shows that a resonant single-mode laser field allows the control the energy of the spin state of an individual Cr atom by using the optical Stark effect. ]

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**Apports personnels, originalité, valorisation, perspectives**  
**Personal contributions, originality, valorization, prospects***Commentaires/comments :*

[The work conducted by Alban LAFUENTE-SAMPIETRO is based on original and sharp experiments, has allowed the obtaining of a great amount of results and rich behaviours which open up the possibility of a complete coherent mechanical driving of the spin of an individual magnetic atom contained in a quantum dot. The results obtained are of first importance and have been summarized in six good quality publications (2 Physical Review B, 2 Physical Review rapid communications, 1Applied Physics Letters, 1 Physica Status Solidi C) in a research field with strong international competition.

I would like to underline the quality of the very fine interpretations of results leading to a detailed understanding of the studied system despite a seemingly puzzling complexity. ]

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**Conclusions du rapporteur / Reviewer's conclusions**

*Commentaires/comments :*

[In conclusion, the thesis manuscript presented by Alban LAFUENTE-SAMPIETRO is of excellent quality and constitutes a highly substantial and very well presented contribution to the field. I judge that work is ready for public presentation and defense to obtain the title of Doctor of Physics at the University of Grenoble Alpes and the University of Tsukuba. ]

**Avis du rapporteur / Reviewer's opinion :**

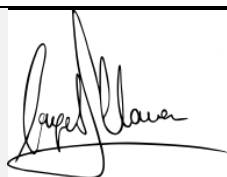
Défavorable à la soutenance / Unfavorable to the defence ☐

Favorable ☒

Date

19/12/2017

Signature

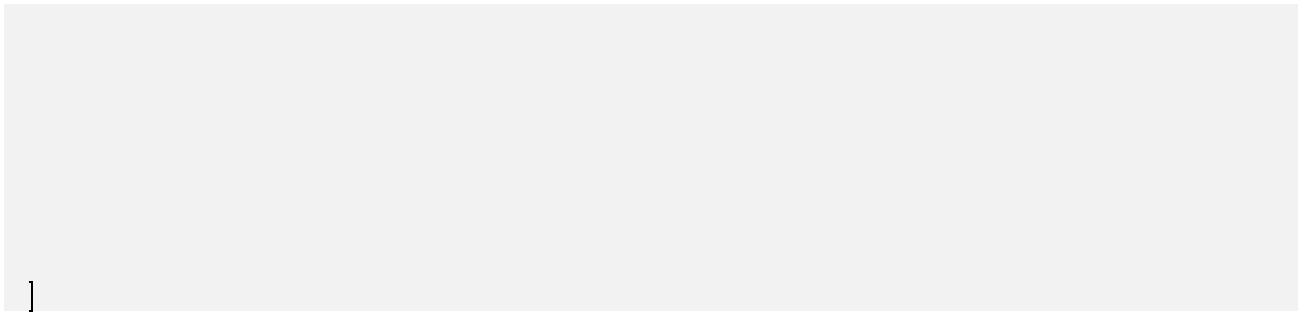
**Visa du directeur de l'école doctorale :**

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**Rapport détaillé, commentaires libres, questionnements, correction demandées**

**Detailed report, free comments, questions, requested corrections**

[Empty area for detailed report, free comments, questions, and requested corrections]



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