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February 3, 2020

## REPORT

by a Member of the Dissertation Committee for the Dissertation by Alexander N. Petrov,  
“Theoretical study of diatomic molecules to search for the electric dipole moment of electron”  
submitted in satisfaction of the requirements for the degree of doctor of physical-mathematical  
sciences in Theoretical Physics (specialization 01.04.02)

It gives me great pleasure to submit this report on the Dissertation by Alexander N. Petrov because this impressive and comprehensive work by the Author is of highest scientific quality and represents a skillful summary of a monumental body of work performed by the Author over the past decade that has provided a solid theoretical basis for the recent breakthroughs in the search for the parity- (P) and time-reversal- (T) violating electric dipole moment of the electron (eEDM) as well as P,T-violating subatomic interactions. Moreover, the work presented in the Dissertation has directly guided experiments, for example, leading to rejection of some candidate molecules initially proposed for experiments in favor of others, as well as in helping control systematic effects by a special choice of experimental parameters such as the value of the electric field at which the experiments are performed.

The Dissertation of A. N. Petrov (presented in full in two languages, Russian and English) consists of nine informative chapters and additional supplemental material.

Chapter 1 provides a crystal-clear introduction to the problems addressed by the work, gives the necessary background, identifies the scope, states the principal results and identifies the Author’s personal contributions (that are central to all the work presented in the Dissertation).

Chapter 2 discusses, in a general way, the effects of the electron EDM in diatomic molecules, distinguishing them from the P,T-odd interactions. In experiment, both effects contribute on equal footing, although their relative size depends on the details of the beyond-the-standard-model interactions.

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Chapters 3 through 8 discuss the specific features and results for a range of molecules of current and potential experimental interest, including the neutral ThO (nonradical neutral) molecule and the HfF+ molecular ion. The ongoing experiments with just these molecules presently provide the most stringent limits on eEDM, currently approaching the hard-to-fathom level of  $10^{-29} e \cdot cm$ , where  $e$  is the magnitude of the elementary charge.

Finally, chapter 9 summarizes the Dissertations and draws conclusions.

While I was generally familiar with A. N. Petrov's work, seeing it beautifully summarized and presented in one comprehensive document has highlighted for me the amazing level of sophistication and true maturity of the theoretical understanding of the highly nontrivial quantum systems with a variety of intertwined interactions as we have in heavy molecules (especially, the ones with hyperfine structure) developed by the Author. I find this work to be overall at the highest level and, in fact, setting the high standard for the field worldwide.

While there is very little to criticize in this Dissertation, I will not deviate from the healthy transition and also offer some (extremely minor) criticisms. First, I always like to see explicit discussions of uncertainties and, in fact, also error bars for any number that is presented, theoretical or experimental. While it is clear that the Author pays proper (central) attention to evaluating uncertainties, it would have probably benefited the Dissertation to add a bit more on this in the text. Second, I have noted a few misprints and grammar issues in the text, for example, the punctuation around equations is not always consistent (some commas and periods are missing), I suspect a misprint in the reference number in Tab. 3.4, a misprint in one of the state labels in Fig. 2.1; there is an apparent misprint also in the molecule name in caption to Tab. 5.5, etc. I need to emphasize once again that these minor issues do not, in any way, diminish my overall positive impression and admiration of this work!

In conclusion, the Dissertation by A. N. Petrov clearly meets and exceeds the high standards for the Doctor dissertations and he fully deserves to be awarded the degree of Doctor of Sciences in Physics and Mathematics.

Диссертация Петрова Александра Николаевича на тему: «Теоретическое исследование двухатомных молекул для поиска электрического дипольного момента электрона» **безусловно соответствует** основным требованиям, установленным Приказом от 01.09.2016 № 6821/1 «О порядке присуждения ученых степеней в Санкт-Петербургском государственном университете», соискатель Петров Александр Николаевич **заслуживает присуждения** ученой степени доктора физико-математических наук по специальности 01.04.02. — Теоретическая физика. Пункт 11 указанного Порядка диссертантом не нарушен.

Sincerely,



Dmitry Budker

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