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To whom it may concern

The Phd thesis entitled 'Direct and Indirect Searches for New Physics in $b \to s\ell\ell$ Decays" presented by Andrea Mauri under the supervision of Prof. Dr. Nicola Serra is a comprehensive and original analysis of how to use Flavour Physics to test the limits of the Standard Model. It hints at one of the most interesting and important topics at present in high energy physics: the possible first discovery of New Physics. This thesis is an excellent and interesting hybrid between an experimental and a theoretical thesis that covers basically two main topics: on the one side, indirect searches for New Physics using semileptonic B decays and on the other, direct searches for an hypothetical new scalar particle produced via the decay $B^+ \to \chi K^+$. The former topic represents a completely novel approach to deal with hadronic uncertainties in the study of the decays $B_0 \to K^{*0}\ell^+\ell^-$ with $\ell = \mu, e$. It is based on the idea that following an amplitude analysis applied to both channels (electron and muon) it is possible to keep all correlations among these two channels reducing the impact of hadronic uncertainties and gaining access to the Wilson coefficient differences between muons and electrons in a cleaner way. In this novel approach the problem of hadronic uncertainties (charm sensitivity and form factors) turns into the problem of finding the right order of the z-expansion and fitting the parameters of this expansion from data. Also several strategies to optimize this search are detailed and explained in the thesis. The latter topic concerns the direct search of a particle contributing to the branching ratio $\mathrm{B}(B^+ \to K^+\chi(\to \mu^+\mu^-))$, for which an upper limit at 95% confidence level is found. Indeed this analysis establishes the most stringent upper limit on this decay improving by one order of magnitude previous analyses and it implies new important constraints on the existence of new light scalar particles.

The coverage of different and non-trivial topics of this thesis in the context of rare B decays shows the wide and in depth knowledge acquired by the student and its robust background. The structure of the thesis is well organized with a complete introduction that covers the two main topics (direct and indirect searches in B physics) and an state-of-the-art description regarding the flavour anomalies. Afterwards an original approach to the flavour anomalies is discussed with particular emphasis on the problem of hadronic uncertainties and focused on Lepton Flavour universal tests. The experimental analysis of the indirect search based on $B \to K^+(K^*)\mu^+\mu-$ is described quite in detail followed by the low-mass di-muon resonance search mentioned above. The thesis ends with the description of the framework of the Amplitude Analysis, including the S-wave contribution, that is used to perform a complete and original analysis of the expected sensitivity to the semileptonic Wilson coefficients C_9 and C_{10}.

The methodology used to explore the different observables is discussed in full detail focusing clearly on its robustness, drawbacks and possible future cross-checks and improvements. Also in the direct fit to Wilson coefficients an innovative framework is introduced that combines machine learning techniques with the standard physics analyses. Undoubtedly the original results and innovative methods presented in this thesis will be of utmost help for our understanding, in a complementary way to other approaches, of the set of observed tensions in Flavour Physics in the important next step that we are facing at present.

For all these reasons I recommend the faculty of science of the University of Zurich to graduate Andrea Mauri to PhD (Dr. sc. nat.).

Yours sincerely,

Prof. Joaquim Matias