



Lay Summary of Thesis

The lay summary is a brief summary intended to facilitate knowledge transfer and enhance accessibility, therefore the language used should be non-technical and suitable for a general audience. [Guidance on the lay summary in a thesis](#). (See the Degree Regulations and Programmes of Study, General Postgraduate Degree Programme Regulations. These regulations are available via: www.drps.ed.ac.uk.)

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| Degree sought: | PhD | No. of words in the main text of thesis: | 21000 |
| Title of thesis: | Lattice determination of semi-leptonic, heavy-light meson decay form factors | | |

Insert the lay summary text here - the space will expand as you type.

The Standard Model (SM) of particle physics is a very elegant model describing the electromagnetic force, weak nuclear decays and the strong nuclear force. It relies heavily on mathematical formulations of symmetry, which provide a great deal of richness and subtlety but can be difficult to work with.

The SM allows very precise predictions in some spheres, e.g. electromagnetism. Yet performing calculations involving the strong nuclear force using our normal mathematical tools involving equations cannot be done at low energies (typical energies seen outside the heart of a star or a particle accelerator) – because the approximations these equations rely on (perturbation theory) are only valid at higher energies.

We do have one way to perform these types of calculations – Lattice Quantum Chromodynamics (LQCD), the theory used in this thesis. LQCD uses a slightly modified (Euclidean) version of the field theory that applies in the everyday world (Minkowski space). Rather than solving equations using approximations, this full theory simulates the fields themselves on a supercomputer using a tiny spacetime grid (with only, for example, 32 positions in each spatial direction and 64 steps in time).

The calculation in this thesis (and the preliminary studies leading up to it) took several years to run and analyse. The result is a pair of “form factors” for one specific weak nuclear decay (from D_s mesons to kaons). These are two smooth curves with energy on the x-axis and a number on the y-axis (between: 0.6557 and 1.000 for the “ f_0 ” form factor; and 0.6557 and 1.592 for the “ f_+ ” form factor). These “non-perturbatively” calculated form factors can be “plugged into” perturbation theory calculations to compute real-world properties mathematically.

In this thesis, the form factors are combined with experimental data to derive a value for a constant of nature called “ V_{cd} ”, which is associated with weak nuclear decays. That is, V_{cd} is one element in a matrix of numbers governing how weak decays “mix up” different generations of matter.

The thesis is highly computational in nature and was performed on supercomputers equipped with GPUs to perform the floating-point calculations. The work might be of interest in more general high-performance computing applications and full code is available at <http://lqcd.me/PhD>.

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