b→u l nu and b→c l nu decays

B → pi l nu, B → D l nu, and friends: 1% precision needed for Belle II in next 5 years. All-HISQ approach already achieved sub-percent precision for decay constants, and should also be applicable to semileptonic form factors of mesons (Also All-Domain Wall calculations). My concern: statistical uncertainties and excited-state contamination, especially for B → pi. Eventually may need to think about QED corrections.

Recently, complete calculation done for B_c to J/psi l nu; R(J/ψ) = 0.2601(36) precise enough for a long time (1.4 percent!).

B → D* l nu form factors at nonzero recoil urgently needed, and coming "soon". D* is stable for most of the lattice data sets, and narrow enough at the physical pion mass so that the stable-hadron treatment is probably very accurate.

Lambda_b → p l nu , Lambda_b → Lambda_c l nu: currently ~ 5 percent uncertainty in |Vub/Vcb| from lattice and also from experiment; 3% lattice uncertainty in R(Lambda_c). But LHCb may reach 1-2 percent for |Vub/Vcb| by 2030. All-HISQ approach not well suited (staggered quarks make calculations with baryons much more complicated). I'm already working on improved calculations. It would be nice to have independent calculations by other groups as well.

Lambda_b → Lambda_c*(2695)l nu, Lambda_b → Lambda_c*(2625) l nu FFs near q^2_max will be published soon.

B → rho (→ pi pi) l nu: can be done using new finite-volume formalism and could also provide useful constraints on right-handed currents. However, s_pipi needs to stay below 4-pi threshold. Can do lattice calculation also for D → rho(→ pi pi) l nu to verify.

B → l nu gamma form factors can be calculated on the lattice in principle. Could also be used to constrain first inverse moment of B-meson light-cone distribution amplitude.

New ideas for inclusive B → X l nu decays on the lattice. Making predictions at physical kinematics requires solving inverse Laplace transform, but there may be other ways of comparing with HQET or experimental data.

Rare b decays

B → K l l and Lambda_b → Lambda l l already in good shape at high q^2, but precision improvements, especially at low q^2 would be welcome.

B → K* (→ K pi) l l needs to be redone using new finite-volume formalism. Again, s_Kpi needs to stay below 3- and 4-particle thresholds.

R_K and R_K* are often said to be essentially form-factor-independent. But that's true only in the Standard Model. The phenomenology of new physics requires knowledge of the form factors.

Lambda_b → Lambda*(1520)ll FFs near q^2_max now available. Not clear how useful.

Nonlocal (charm) contributions cannot yet be calculated on the lattice, although there is some preliminary work in progress.

B_s-\bar{B_s} mixing

Often sensitive to the same new physics as considered for rare b decays. Constraints can be made much stronger with improved lattice calculations.