Radiative & Electroweak Penguins

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Section Outline

- Theory (4 pages)
- Inclusive $b \to s\gamma$ (6 pages)
- Exclusive $b \to s\gamma$ (4 pages)
- Exclusive & inclusive $b \to d\gamma$ (3 pages)
- Time-dependent CP violation in $b \to s(d)\gamma$ (3 pages)
- Exclusive & inclusive $b \to s l^+l^-$ (6 pages)
- Exclusive $b \to s \nu \bar{\nu}$ (2 pages)
- Other decays ($\gamma\gamma$, $\pi l^+ l$) ? (2 pages)

Progress in writing

Nothing written explicitly for this book yet, but …

- Hurth & Nakao (arXiv: 1005.1224)
  to appear in Ann.Rev.Nucl.Sci.
  ~ 18 pages of theory, ~12 pages of experiment
- Playfer & Robertson
  invited to review rare b decays by Rev.Mod.Phys.
  anticipate ~10 pages theory, ~25 pages experiment

Need to summarize (and update?) very nice theory discussion from Hurth & Nakao at a level suitable for B factory book

Need to update experimental discussion to include final results from BaBar and Belle

Theory issues

- How much theory is specific to radiative & electroweak penguins?
  - Predictions for individual decay modes
  - NNLO and non-perturbative contributions
- How much will the more general theory be covered elsewhere in the book?
  - Operator Product Expansion
  - Form Factors
  - Shape Functions
  - New Physics

Theory updates

- Inclusive $b \to s\,\gamma$
  - More NNLO (Misiak & Steinhausen arXiv:1005.1173, Asatrian et al arXiv:1005.5587)
  - Operator mixing (Ewerth et al arXiv: 0911.2175, Benzke et al arXiv: 1003.5102)
  - Branching fraction prediction limited by non-perturbative power corrections at 5% level
  - Ongoing work on CP asymmetries and spectral shape (G.Paz, F.Tackmann, CKM workshop)
- Inclusive $b \to s\,l^+l^-$
  - NNLO in SCET (Bell et al, arXiv: 1007.3758)
- Exclusive $b \to s\,l^+l^-$
  - $B \to K^*$ form factors (Khodjamirian, CKM workshop)
  - New angular observables (Egede et al, arXiv: 1005.0571)
- Exclusive $b \to s\,\nu\,\nu$
  - NNLO (Brod et al, arXiv: 1009.0947)
- New Physics models
  - Review by Isidori, Nir & Perez (arXiv: 1002.0900)
  - Fourth generation (Buras et al, arXiv: 1002.2126, 1004.4565)
  - Right-handed currents (Buras et al, arXiv: 1007.1993)
  - Higgs mediated FCNCs (Buras et al, arXiv: 1005.5310)

  … and many other groups and models!

New experimental results

BaBar:

- Inclusive $b \to d\gamma$ with full dataset (arXiv: 1005.4087, PRD82:051101)
- Semileptonic-tagged $B \to K \nu \nu$ (arXiv: 1009.1529, submitted to PRD)
- Hadronic-tagged $B \to K \tau^+\tau^-$ (preliminary results shown at ICHEP)
- Inclusive $b \to s\gamma$ with 350/fb (preliminary results shown at CKM)
- $B \to \gamma\gamma$ (new upper limit to be submitted for publication shortly)

Belle:

- Exclusive $B \to \phi K \gamma$ with 700/fb (arXiv: 0911.1779)
- Inclusive $b \to s\, l^+l^-$ with 600/fb (preliminary results shown Lepton/Photon 2009)

… and not completely ignoring:

CDF:

- Exclusive $B \to K^{*0}\mu^+\mu^-$ (CDF note 10047, July 2010)

Experimental results still awaited

BaBar:

- Final inclusive $b \rightarrow s\gamma$ (BF & spectral shape)
- Final $B \rightarrow K^* l^+ l^-$ (BF, asymmetries, angular distribution)
- Inclusive $b \rightarrow s\, l^+ l^-$

Belle:

- Final inclusive $b \rightarrow s\, l^+ l^-$
- Sum of exclusives $b \rightarrow s\gamma$ & $b \rightarrow d\gamma$
- Update of $B \rightarrow K^* l^+ l^-$? (Current results on 600/fb)

BaBar & Belle:

- Improved limits on $B \rightarrow K(*)\, \nu\, \nu$ (Full datasets & combined tags)

World Averages

- HFAG average BF($b \to s\gamma$) unsatisfactory

  (limosani, playfer, paz, tackmann)

  - Outdated extrapolation to $E_\gamma > 1.6$GeV
  - Inconsistent shape function parameters
  - Non-optimal use of experimental information from higher E_γ thresholds
- No averages for A_{FB} and F_L in K*ll (BaBar, Belle, CDF)
  - Theorists favour region $1 < q^2 < 6$ GeV^2
  - No public results from BaBar for this region
- Would be advantageous to combine data samples
  - Results on A_{FB}, F_L in K*ll for more bins in q^2
  - Better upper limits on unseen decays, e.g. $\pi l^+ l^-$ and K(*)$\nu\nu$
  - Not likely to happen soon!