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$b \to d$ and other charmless B decays at Belle

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We report a search for the decays $B^- \to K^{*0}K^-$, $B^0 \to K^{*0}\overline{K}^{*0}$ and $B^0 \to K^{*0}K^{*0}$. We also measure other charmless decay modes with $K^+K^-\pi^-$, $K^+\pi^-K^-\pi^+$ and $K^+\pi^-K^+\pi^-$ final states. These results are obtained from a data sample containing 657×10^6 $B\overline{B}$ pairs collected with the Belle detector at the KEKB asymmetric-energy e^+e^- collider. We measured the branching fraction for $B^- \to K^{*0}K^-$ to be $(0.68 \pm 0.16 \pm 0.1) \times 10^{-6}$ with 4.4σ significance, and set an upper limit on the branching fractions for $B^- \to K^*_{0/2}(1430)K^-$, $B^0 \to K^{*0}\overline{K}^{*0}$ and $B^0 \to K^{*0}K^{*0}$ of 1.1×10^{-6}, 0.81×10^{-6} and 0.2×10^{-6}, respectively, at the 90% confidence level (C.L.).

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In the standard model (SM), the rare decay $B \to K^*K$ is dominated by $b \to d$ gluonic "penguin" transition. Such a flavor-changing neutral current (FCNC) process provides a key element in the testing of the quark-flavor sector of the SM [1, 2, 3]. This mode is also relevant for the interpretation of the time dependent CP asymmetry obtained with the $B^0 \to \phi K^0_S$. A method [4] is introduced to place a bound on $\Delta S_{\phi K^0_S}$ by exploiting SU(3) flavor symmetry and combining measured rates for relevant $b \to s$ and $b \to d$ (including $B \to K^*K$) processes.

The charmless decay $B^0 \to K^{*0}\overline{K}^{*0}$ proceeds through electroweak and gluonic $b \to d$ penguin loop diagrams. For a B meson decaying to two vector particles, $B \to VV$, theoretical models in the framework of QCD factorization and perturbative QCD predict the fraction of longitudinal polarization (f_L) to be ~ 0.9 for tree-dominated decays and ~ 0.75 for penguin-dominated decays [5, 6]. However, the measured polarization fraction in the pure penguin decay $B \to \phi K^*$ has a somewhat lower value of $f_\mathrm{L} \sim 0.5$ [7]. This unexpected result has motivated further studies [8]. One resolution to this puzzle is a smaller $B \to K^*$ form factor that could reduce f_L significantly [9]. If this explanation is correct, the penguin-dominated decay $B^0 \to K^{*0}\overline{K}^{*0}$ should exhibit a similar polarization fraction. The $B^0 \to K^{*0}\overline{K}^{*0}$ mode can also be used to extract the branching fraction corresponding to the longitudinal helicity final state, determine hadronic parameters for the $b \to s$ decay $B_s \to K^{*0}\overline{K}^{*0}$, and help constrain the angles ϕ_2 (α) and ϕ_3 (γ) of the Cabibbo-Kobayashi-Maskawa unitarity triangle [10]. The topologically similar decay $B^0 \to K^{*0}K^{*0}$ is forbidden in the Standard Model (SM); its observation would indicate new physics.

The B meson candidates are reconstructed from combinations of three and four charged tracks. Charged kaons and pions are identified using particle identification (PID) information obtained from the CDC (dE/dx), ACC, and TOF. We distinguish charged kaons and pions using a likelihood ratio $\mathscr{R}_\mathrm{PID} = \mathscr{L}_K/(\mathscr{L}_K + \mathscr{L}_\pi)$, where $\mathscr{L}_\pi(\mathscr{L}_K)$ is the likelihood value for the pion (kaon) hypothesis. The signal event candidates are characterized by two kinematic variables: the beam-energy-constrained mass, $M_\mathrm{bc} = \sqrt{E^2_\mathrm{beam} - P^{*2}_B}$, and the energy difference, $\Delta E = E^*_B - E_\mathrm{beam}$, where E_beam is the run-dependent beam energy, and P^*_B and E^*_B are the momentum and energy of the B candidate in the $\Upsilon(4S)$ center-of-mass (CM) frame.

For our analysis of $B^- \to K^*K^-$, $B^0 \to K^{*0}\overline{K}^{*0}$ and $B^0 \to K^{*0}K^{*0}$, we reconstruct $K^{*0} \to K^+\pi^-$ and $\overline{K}^{*0} \to K^-\pi^+$. We distinguish nonresonant $B^- \to KK\pi$ and $B^0 \to KK\pi\pi$ decays from our signal modes by fitting the one- and two-dimensional mass distributions $M(K^+\pi^-)$, $M(K^+\pi^-)$ vs. $M(K^-\pi^+)$ or $M(K^+\pi^-)$ vs. $M(K^+\pi^-)$. The signal yields for $B^- \to K^*K^-$ are extracted by performing extended unbinned maximum likelihood (ML) fits to the variables M_bc, ΔE and $M(K^+\pi^-)$; the signal yields for $B^0 \to K^{*0}\overline{K}^{*0}$ are extracted by ML fits to the variables M_bc, ΔE, $M(K^+\pi^-)$, and $M(K^-\pi^+)$. The three-dimensional fit discriminates among $K^{*0}K$, $K^*_{0/2}(1430)K$, and nonresonant $K\pi\pi$; and the four-dimensional fit discriminates among $K^{*0}\overline{K}^{*0}$, $K^{*0}K\pi$, $K^*_0(1430)\overline{K}^*_0(1430)$, $K^*_0(1430)\overline{K}^{*0}$, $K^*_0(1430)K\pi$, and nonresonant $KK\pi\pi$ final states [$K^*_2(1430)X$ modes are only considered in the systematics due to the large statistical correlations with $K^*_0(1430)X$ modes].

The projections of the fit superimposed to the data are shown in figures 1-3. In summary, we measured the branching fraction for $B^- \to K^{*0}K^-$ to be $(0.68 \pm 0.16 \pm 0.1) \times 10^{-6}$ with 4.4σ significance, and set an 90% C.L. upper limit on the branching fractions for $B^- \to K^*_{0/2}(1430)K^-$ of 1.1×10^{-6}. On the other hand, we measure the branching fraction for $B^0 \to K^{*0}\overline{K}^{*0}$ to be $(0.26^{+0.33+0.10}_{-0.29-0.07}) \times 10^{-6}$ with 0.9σ significance. The 90% C.L. upper limits including systematic uncertainties for $B^0 \to K^{*0}\overline{K}^{*0}$ and $B^0 \to K^{*0}K^{*0}$ are 0.81×10^{-6} and 0.2×10^{-6}, respectively. These values correspond to a longitudinal polarization fraction $f_L = 1$; as the efficiency for $f_L = 0$ is higher than that for $f_L = 1$, our upper limit is conservative. Our measured branching fraction for $B^0 \to K^{*0}\overline{K}^{*0}$ mode differs from that obtained by BaBar [11] by 2.2σ. We find no significant signals for the other charmless decay modes with $K^+\pi^-K^-\pi^+$ final states; the corresponding upper limits are listed in Table 1.

Table 1: Fit results for decay modes with a final state $K^+\pi^-K^-\pi^+$. The efficiency ε includes branching fractions for subdecays $K^{*0} \to K^+\pi^-$ and $K_0^*(1430) \to K^+\pi^-$ (66.5% and 66.7%, respectively), and the significance $\mathscr{S}$ is in units of σ. The first (second) error listed is statistical (systematic).

Mode	Yield	ε (%)	$\mathscr{S}$	$\mathscr{B} \times 10^6$	UL $\times 10^6$
$B^0 \to K^{*0}\overline{K}^{*0}$	$7.7^{+9.7+2.8}_{-8.5-2.0}$	4.43 ($f_L = 1.0$)	0.9	$0.26^{+0.33+0.10}_{-0.29-0.07}$	< 0.81
$B^0 \to K^{*0}K\pi$	$18.2^{+48.4+41.6}_{-45.3-40.7}$	1.31	0.3	$2.11^{+5.63+4.84}_{-5.26-4.73}$	< 13.88
$B^0 \to K_0^*(1430)\overline{K}_0^*(1430)$	$78.5^{+70.6+56.1}_{-69.6-56.5}$	3.72	0.8	$3.21^{+2.89+2.30}_{-2.85-2.31}$	< 8.36
$B^0 \to K_0^*(1430)\overline{K}^{*0}$	$19.6^{+31.1+40.0}_{-31.0-42.9}$	4.38	0.4	$0.68 \pm 1.08^{+1.39}_{-1.49}$	< 3.33
$B^0 \to K_0^*(1430)K\pi$	$-222.8^{+171.5+159.5}_{-170.8-168.6}$	1.34	—	—	< 31.80
Nonresonant $B^0 \to KK\pi\pi$	$158.4^{+120.6+103.9}_{-117.8-104.9}$	0.82	1.0	$29.41^{+22.39+19.28}_{-21.87-19.48}$	< 71.74

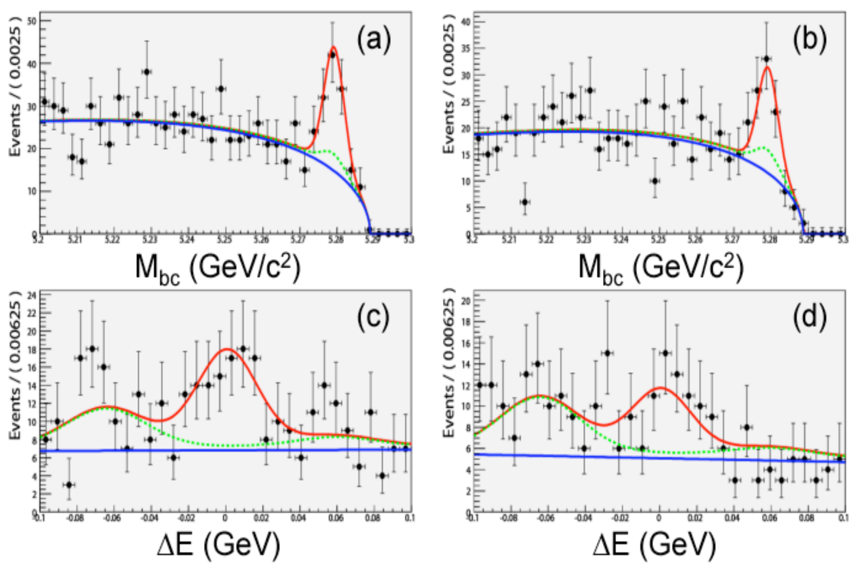

Figure 1: (a) and (c): Projections of the fit onto M_{bc} and ΔE for $B^- \to K^{*0}K^-$ decays; (b) and (d): Projections of the fit onto M_{bc} and ΔE for $B^- \to K_{0/2}^*(1430)K^-$ decays, these are for candidates satisfying (except for the variable plotted) $\Delta E \in [-0.043,\ 0.043]$ GeV and $M_{bc} \in [5.271,\ 5.287]$ GeV$/c^2$. The light solid curve shows the overall fit result; the solid and dashed curves represent continuum background and charmless B decay background, respectively.

References

[1] R. Fleischer and S. Recksiegel, Phys. Rev. D **71**, 051501 (2005); Proc. Sci., HEP2005 (2006) 255.

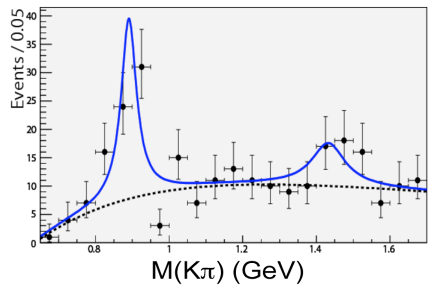

Figure 2: Background substracted $M(K\pi)$ distribution for $B \to KK\pi$ mode. The yield of $B \to K^{*0}K$, $B \to K^*_{0/2}(1430)K$ and nonresonant $B \to KK\pi$ are determined from $M(K\pi)$ fit.

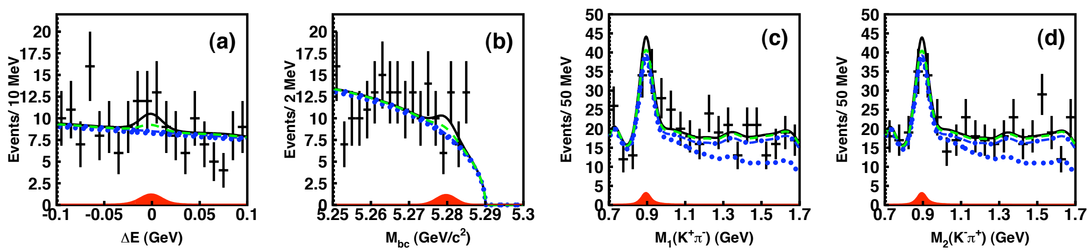

Figure 3: Projections of the four-dimensional fit onto (a) ΔE, (b) $M_{\rm bc}$, (c) $M(K^+\pi^-)$, and (d) $M(K^-\pi^+)$ for $B^0 \to K^{*0}\overline{K}^{*0}$ decays, these are for candidates satisfying (except for the variable plotted) $\Delta E \in [-0.045,\ 0.045]$ GeV, $M_{\rm bc} \in [5.27,\ 5.29]$ GeV$/c^2$, and $M_{1,2}(K\pi) \in [0.826,\ 0.966]$ GeV$/c^2$. The thick solid curve shows the overall fit result; the solid shaded region represents the $B^0 \to K^{*0}\overline{K}^{*0}$ signal component; the dotted, dot-dashed and dashed curves represent continuum background, $b \to c$ background, and charmless B decay background, respectively.

[2] C.-W. Chiang et al., Phys. Rev. D **69**, 034001 (2004).

[3] L. Guo et al., Phys. Rev. D **75**, 014019 (2007).

[4] Y. Grossman et al., Phys. Rev. D **68**, 015004 (2003).

[5] A. Ali *et al.*, Z. Phys. C **1**, 269 (1979); M. Suzuki, Phys. Rev. D **66**, 054018 (2002).

[6] C.H. Chen, Y.Y. Keum, and H-n. Li, Phys. Rev. D **66**, 054013 (2002).

[7] K.-F. Chen *et al.* (Belle Collaboration), Phys. Rev. Lett. **94**, 221804 (2005); B. Aubert (BaBar Collaboration), Phys. Rev. Lett. **98** 051801 (2007).

[8] A. Kagan, Phys. Lett. B **601**, 151 (2004); C. Bauer *et al.*, Phys. Rev. D **70**, 054015 (2004); P. Colangelo *et al.*, Phys. Lett. B **597**, 291 (2004); M. Ladisa *et al.*, Phys. Rev. D **70**, 114025 (2004); H.-n. Li and S. Mishima, Phys. Rev. D **71**, 054025 (2005); M. Beneke *et al.*, Phys. Rev. Lett. **96**, 141801 (2006).

[9] H-n. Li, Phys. Lett. B **622**, 63-68 (2005).

[10] D. Atwood and A. Soni, Phys. Rev. D **65**, 073018 (2002); S. Descotes-Genon, J. Matias and J. Virto, Phys. Rev. D **76**, 074005 (2007).

[11] B. Aubert (BaBar Collaboration), Phys. Rev. Lett. **100**, 081801 (2008).