Measurement of the exclusive branching fractions $B^0 \rightarrow \eta K^*0$ and $B^+ \rightarrow \eta K^{*+}$.

The BABAR Collaboration

November 6, 2018

Abstract

We present the results of searches for $B$ decays to the two charmless two-body final states $B^0 \rightarrow \eta K^*0$ and $B^+ \rightarrow \eta K^{*+}$, based on 20.7 fb$^{-1}$ of data collected in 1999 and 2000 with the BABAR detector at PEP-II. We find the branching fractions $\mathcal{B}(B^0 \rightarrow \eta K^*0) = (19.8^{+6.5}_{-5.6} \pm 1.7) \times 10^{-6}$ and $\mathcal{B}(B^+ \rightarrow \eta K^{*+}) = (22.1^{+11.1}_{-9.2} \pm 3.3) \times 10^{-6}$, where the first error quoted is the statistical and the second systematic.

Submitted to the International Europhysics Conference on High Energy Physics, 7/12—7/18/2001, Budapest, Hungary

Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309

Work supported in part by Department of Energy contract DE-AC03-76SF00515.
The BABAR Collaboration,

B. Aubert, D. Boutigny, J.-M. Gaillard, A. Hicheur, Y. Karyotakis, J. P. Lees, P. Robbe, V. Tisserand
Laboratoire de Physique des Particules, F-74941 Annecy-le-Vieux, France

A. Palano
Università di Bari, Dipartimento di Fisica and INFN, I-70126 Bari, Italy

G. P. Chen, J. C. Chen, N. D. Qi, G. Rong, P. Wang, Y. S. Zhu
Institute of High Energy Physics, Beijing 100039, China

G. Eigen, P. L. Reinertsen, B. Stugu
University of Bergen, Inst. of Physics, N-5007 Bergen, Norway

B. Abbott, G. S. Abrams, A. W. Borgland, A. B. Breon, D. N. Brown, J. Button-Shafer, R. N. Cahn, A. R. Clark, M. S. Gill, A. V. Gritsan, Y. Groysman, R. G. Jacobsen, R. W. Kadel, J. Kadyk, L. T. Kerth, S. Kluth, Yu. G. Kolomensky, J. F. Kral, C. LeClerc, M. E. Levi, T. Liu, G. Lynch, A. B. Meyer, M. Momayezi, P. J. Oddone, A. Perazzo, M. Pripstein, N. A. Roe, A. Romosan, M. T. Ronan, V. G. Shellkov, A. V. Telnov, W. A. Wenzel
Lawrence Berkeley National Laboratory and University of California, Berkeley, CA 94720, USA

P. G. Bright-Thomas, T. J. Harrison, C. M. Hawkes, D. J. Knowles, S. W. O’Neale, R. C. Penny, A. T. Watson, N. K. Watson
University of Birmingham, Birmingham, B15 2TT, United Kingdom

T. Deppermann, K. Goetzen, H. Koch, J. Krug, M. Kunze, B. Lewandowski, K. Peters, H. Schmuecker, M. Steinke
Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany

J. C. Andress, N. R. Barlow, W. Bhimji, N. Chevalier, P. J. Clark, W. N. Cottingham, N. De Groot, N. Dyce, B. Foster, J. D. McFall, D. Wallom, F. F. Wilson
University of Bristol, Bristol BS8 1TL, United Kingdom

K. Abe, C. Hearty, T. S. Mattison, J. A. McKenna, D. Thiessen
University of British Columbia, Vancouver, BC, Canada V6T 1Z1

S. Jolly, A. K. McKemey, J. Tinslay
Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom

V. E. Blinov, A. D. Bukin, D. A. Bukin, A. R. Buzyaev, V. B. Golubev, V. N. Ivanchenko, A. A. Korol, E. A. Kravchenko, A. P. Onuchin, A. A. Salnikov, S. I. Serednyakov, Yu. I. Skovpen, V. I. Telnov, A. N. Yushkov
Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

D. Best, A. J. Lankford, M. Mandelkern, S. McMahon, D. P. Stoker
University of California at Irvine, Irvine, CA 92697, USA

A. Ahsan, K. Arisaka, C. Buchanan, S. Chun
University of California at Los Angeles, Los Angeles, CA 90024, USA
J. G. Branson, D. B. MacFarlane, S. Prell, Sh. Rahatlou, G. Raven, V. Sharma

University of California at San Diego, La Jolla, CA 92093, USA

C. Campagnari, B. Dahmes, P. A. Hart, N. Kuznetsova, S. L. Levy, O. Long, A. Lu, J. D. Richman, W. Verkerke, M. Witherell, S. Yellin

University of California at Santa Barbara, Santa Barbara, CA 93106, USA

J. Beringer, D. E. Dorfan, A. M. Eisner, A. Frey, A. A. Grillo, M. Grothe, C. A. Heusch, R. P. Johnson, W. Kroeger, W. S. Lockman, T. Pulliam, H. Sadrozinski, T. Schalk, R. E. Schmitz, B. A. Schumm, A. Seiden, M. Turri, W. Walkowiak, D. C. Williams, M. G. Wilson

University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, CA 95064, USA

E. Chen, G. P. Dubois-Felsmann, A. Dvoretskii, D. G. Hitlin, S. Metzler, J. Oyang, F. C. Porter, A. Ryd, A. Samuel, M. Weaver, S. Yang, R. Y. Zhu

California Institute of Technology, Pasadena, CA 91125, USA

S. Devmal, T. L. Geld, S. Jayatilleke, G. Mancinelli, B. T. Meadows, M. D. Sokoloff

University of Cincinnati, Cincinnati, OH 45221, USA

T. Barillari, P. Bloom, M. O. Dina, S. Fahey, W. T. Ford, D. R. Johnson, U. Nauenberg, A. Olivas, H. Park, P. Rankin, J. Roy, S. Sen, J. G. Smith, W. C. van Hoek, D. L. Wagner

University of Colorado, Boulder, CO 80309, USA

J. Blouw, J. L. Harton, M. Krishnamurthy, A. Soffer, W. H. Toki, R. J. Wilson, J. Zhang

Colorado State University, Fort Collins, CO 80523, USA

T. Brandt, J. Brose, T. Colberg, G. Dahlinger, M. Dickopp, R. S. Dubitzky, A. Hauke, E. Maly, R. Müller-Pfefferkorn, S. Otto, K. R. Schubert, R. Schwierz, B. Spaan, L. Wilden

Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062, Dresden, Germany

L. Behr, D. Bernard, G. R. Bonneaud, F. Brochard, J. Cohen-Tanugi, S. Ferrag, E. Roussot, S. T’Jampens, Ch. Thiebaux, G. Vasileiadis, M. Verderi

Ecole Polytechnique, F-91128 Palaiseau, France

A. Anjomshoaa, R. Bernet, A. Khan, D. Lavin, F. Muheim, S. Playfer, J. E. Swain

University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

M. Falbo

Elon University, Elon University, NC 27244-2010, USA

C. Borean, C. Bozzi, S. Dittongo, M. Folegani, L. Piemontese

Università di Ferrara, Dipartimento di Fisica and INFN, I-44100 Ferrara, Italy

E. Treadwell

Florida A&M University, Tallahassee, FL 32307, USA

F. Anulli, R. Baldini-Ferroli, A. Calcaterra, R. de Sangro, D. Falciai, G. Finocchiaro, P. Patteri, I. M. Peruzzi, M. Piccolo, Y. Xie, A. Zallo

Laboratori Nazionali di Frascati dell’INFN, I-00044 Frascati, Italy

1 Also with Università di Perugia, I-06100 Perugia, Italy
B. Brau, R. Cowan, G. Sciolla, F. Taylor, R. K. Yamamoto

Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, MA 02139, USA

M. Milek, P. M. Patel, J. Trischuk

McGill University, Montréal, Canada QC H3A 2T8

F. Lanni, F. Palombo

Università di Milano, Dipartimento di Fisica and INFN, I-20133 Milano, Italy

J. M. Bauer, M. Booke, L. Cremaldi, V. Eschenburg, R. Kroeger, J. Reidy, D. A. Sanders, D. J. Summers

University of Mississippi, University, MS 38677, USA

J. P. Martin, J. Y. Nief, R. Seitz, P. Taras, A. Woch, V. Zacek

Université de Montréal, Laboratoire René J. A. Lévesque, Montréal, Canada QC H3C 3J7

H. Nicholson, C. S. Sutton

Mount Holyoke College, South Hadley, MA 01075, USA

C. Cartaro, N. Cavallo, G. De Nardo, F. Fabozzi, C. Gatto, L. Lista, P. Paolucci, D. Piccolo, C. Sciacca

Università di Napoli Federico II, Dipartimento di Scienze Fisiche and INFN, I-80126, Napoli, Italy

J. M. LoSecco

University of Notre Dame, Notre Dame, IN 46556, USA

J. R. G. Alsmiller, T. A. Gabriel, T. Handler

Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

J. Brau, R. Frey, M. Iwasaki, N. B. Sinev, D. Strom

University of Oregon, Eugene, OR 97403, USA

F. Colecchia, F. Dal Corso, A. Dorigo, F. Galeazzi, M. Margoni, G. Michelon, M. Morandin, M. Posocco, M. Rotondo, F. Simonetto, R. Stroili, E. Torassa, C. Voci

Università di Padova, Dipartimento di Fisica and INFN, I-35131 Padova, Italy

M. Benayoun, H. Briand, J. Chauveau, P. David, Ch. de la Vaissière, L. Del Buono, O. Hamon, F. Le Diberder, Ph. Leruste, J. Lory, L. Roos, J. Stark, S. Versillé

Universités Paris VI et VII, Lab de Physique Nucléaire H. E., F-75252 Paris, France

P. F. Manfredi, V. Re, V. Speziali

Università di Pavia, Dipartimento di Elettronica and INFN, I-27100 Pavia, Italy

E. D. Frank, L. Gladney, Q. H. Guo, J. H. Panetta

University of Pennsylvania, Philadelphia, PA 19104, USA

C. Angelini, G. Batignani, S. Bettarini, M. Bondioli, M. Carpinelli, F. Forti, M. A. Giorgi, A. Lusiani, F. Martinez-Vidal, M. Morganti, N. Neri, E. Paoloni, M. Rama, G. Rizzo, F. Sandrelli, G. Simi, G. Triggiani, J. Walsh

Università di Pisa, Scuola Normale Superiore and INFN, I-56010 Pisa, Italy

3 Also with Università della Basilicata, I-85100 Potenza, Italy
1 Introduction

We report results for searches for $B$ decays to the charmless two-body final states $B^0 \rightarrow \eta K^{*0}$ and $B^+ \rightarrow \eta K^{*+}$. These processes are manifestations of penguin or suppressed tree amplitudes proportional to small couplings in hadronic flavor mixing (CKM matrix). As more of these rare decay modes are measured, their phenomenological description will improve, and with it the sensitivity to any contributions through virtual particle loops or interference terms of heretofore undetected physics.

2 The $\textit{BaBar}$ detector and dataset

The data were collected with the $\textit{BaBar}$ detector at the PEP-II storage ring located at the Stanford Linear Accelerator Center. The results presented in this paper are based on data taken in the 1999–2000 run. An integrated luminosity of 20.7 fb$^{-1}$ was recorded at the $\Upsilon(4S)$ resonance corresponding to 22.7 million $B\overline{B}$ pairs (“on-resonance”). In addition 2.6 fb$^{-1}$ was recorded about 40 MeV below this energy (“off-resonance”) to study non-$b\overline{b}$ continuum.

The asymmetric beam configuration in the laboratory frame provides a boost to the $\Upsilon(4S)$ increasing the momentum range of the $B$-meson decay products up to 4.3 GeV/$c$. Charged particles are detected and their momenta are measured by a combination of a silicon vertex tracker (SVT) consisting of five double-sided layers and a 40-layer drift chamber (DCH), both operating in a 1.5 T solenoidal magnetic field. Photons are detected by a CsI electromagnetic calorimeter (EMC), which provides excellent angular and energy resolution with high efficiency for energies above 20 MeV.

Charged particle identification (PID) is provided by the specific ionization loss ($dE/dx$) in the tracking devices and by a unique, internally reflecting ring imaging Cherenkov detector (DIRC) covering the central region. A Cherenkov angle $K^–\pi$ separation of better than 4$\sigma$ is achieved for tracks below 3 GeV/$c$ momentum, decreasing to 2.5$\sigma$ at the highest momenta in our final states.

3 Analysis method

We reconstruct a $B$ meson candidate by combining an $\eta$ candidate with a $K^*$ candidate. The daughter resonance decays are $\eta \rightarrow \gamma\gamma$, $K^{*0} \rightarrow K^+\pi^-$, $K^{*+} \rightarrow K^0\pi^+$ and $K^0_\pi \rightarrow \pi^+\pi^-$. These modes are kinematically distinct from the dominant $B$ decays to heavier charmed daughters. Backgrounds come primarily from combinatorics among continuum events in which a light quark pair was produced instead of an $\Upsilon(4S)$.

Monte Carlo (MC) simulations of the target decay modes and of continuum background were used to establish the event selection criteria. They were designed to achieve high efficiency and retain sidebands sufficient to characterize the background for subsequent fitting. Photons must satisfy $E_{\gamma} > 50$ MeV for $\eta$ candidates. We select $\eta$ and $K^*$ candidates with the requirements $490 < m_{\gamma\gamma} < 600$ MeV/$c^2$, and $800 < m_{K\pi} < 990$ MeV/$c^2$. For $K^0_S$ candidates we require $400 < m_{\pi\pi} < 600$ MeV/$c^2$.

The pion (kaon) daughters of the $K^*$ candidates must have DIRC, $dE/dx$, and EMC responses consistent with pions (kaons). For the $K^0_S$, the three-dimensional flight distance from the event primary vertex must exceed 2 mm, the two-dimensional angle between the flight and momentum vectors must be less than 40 mrad and the lifetime significance ($\tau/\sigma_\tau$) should be larger than 3.
A $B$ meson candidate is characterized by two kinematic observables. In the CMS system, due to the two-body nature of the $B$ meson production at the $\Upsilon(4S)$, the $B$ meson candidate’s energy $E^*_B$ must be equal to $\sqrt{s}/2$, where $\sqrt{s}$ is the center of mass energy. This is taken into account by requiring that $|\Delta E| = |E^*_B - \sqrt{s}/2|$ be less than 0.2 GeV, and the beam energy constrained mass $m_{EC} = \sqrt{\hat{E}^*_B - \hat{p}^*_B}$, where $\hat{E}^*_B$ and $\hat{p}^*_B$ are values obtained from a kinematic fit with the constraint $E^*_B = \sqrt{s}/2$.

To discriminate against tau-pair and two-photon background we require the event to contain at least three (four) charged tracks for neutral (charged) $B$ meson candidates. To reject continuum background we make use of the angle $\theta_T$ between the thrust axis of the $B$ candidate and the rest of the tracks and neutral clusters in the event, calculated in the center-of-mass frame. The distribution of $\cos \theta_T$ is sharply peaked near $\pm 1$ for combinations drawn from jetlike $q\bar{q}$ pairs, and nearly uniform for the isotropic $B$ meson decays. We require $|\cos \theta_T| \leq 0.9$.

Event yields are obtained by an unbinned extended maximum likelihood (ML) fit analysis, while requirement based analyses are used to validate the results. The input observables are $\Delta E, m_{EC}$, the invariant masses $m_{\gamma\gamma}$ and $m_{K\pi}$ of the two resonant daughter candidates and a Fisher discriminant $F$. The $K^0_S$ spectrum is not fitted because candidates in the background are dominantly real $K^0_S$.

The Fisher discriminant $F$ combines two production angles and a nine bin representation of the energy flow about the $B$ decay axis. For the $\eta$ mode the helicity angle $\theta^\text{hel}_\eta$ is the angle in the $\eta$ rest frame between the direction of one of the photons and the $\eta$ flight direction. We require $\cos \theta^\text{hel}_\eta \leq 0.92$ to discriminate against $K^*\gamma$ background. A second $B$ candidate satisfying the preliminary requirements occurs in about 11% of the events. In this case the “best” combination is selected according to a $\chi^2$ computed from $m_\eta$ and $m_{K^*}$.

The requirement based analyses use the same variables as the ML fit with tighter selection criteria for the signal. A large sideband in the $m_{ES}, \Delta E$ plane gives an estimate of the continuum background which, with appropriate scaling, is subtracted from the raw signal yield.

We use MC to estimate backgrounds from other $B$ decays, including modes with and without charmed daughters. We find these contributions to be negligible.

The likelihood function for $N$ observed events is

$$L = \frac{e^{-(\sum n_j)}}{N!} \prod_{i=1}^{N} L_i,$$

where the contribution of event $i$ is

$$L_i = \sum_{j=1}^{m} n_j P_j(\vec{x}_i).$$

Here $n_j$ is the population size for species $j$ (e.g., signal, background) and $P_j(\vec{x}_i)$ the corresponding probability distribution function (PDF), evaluated with the observables $\vec{x}_i$ of the $i$th event.

For the fits $L_i$ becomes (with the event index $i$ suppressed on both sides of the equation)

$$L = n_S P_S + n_C P_C,$$

where $n_S$ is the number of signal events and $n_C$ is the number of continuum background events. These quantities are the free parameters of the ML fit. The probabilities for the components are $P_S$ for signal and $P_C$ for background. Since we measure the correlations among the observables in the data to be small, we take each $P_j$ to be a product of the PDFs for the separate observables.

We determine the PDFs for the likelihood fit from simulation for the signal component, and off-resonance and on-resonance sideband data for the continuum background. Peaking distributions
(signal masses, $\Delta E, \mathcal{F}$) are parameterized as “crystal ball shape” [5], double Gaussian or bifurcated Gaussian functions. Slowly varying distributions (combinatoric background under mass or energy peaks) have polynomial shapes. The combinatoric background in $m_{EC}$ is described by a phase space motivated empirical function [6], the Argus shape. Control samples of $B$ decays to charmed final states of similar topology are used to verify the simulated resolutions in $\Delta E$ and $m_{EC}$.

4 Results

We compute the branching fractions from the fitted signal event yields, reconstruction efficiency, daughter branching fractions, and the number of produced $B$ mesons, assuming equal production rates of charged and neutral pairs. In Figure 1 the Likelihood function for the two modes is plotted.

![Likelihood functions for $B^0 \to \eta K^*$ and $B^+ \to \eta K^{++}$](image)

Figure 1: likelihood functions for $B^0 \to \eta K^*$ (left) and $B^+ \to \eta K^{++}$ (right) branching fractions.

Table 1 shows for both decay chains the branching fraction we measure, together with the quantities entering into its computation. The statistical error on the number of events is taken as the shift from the central value that changes the quantity $\chi^2 \equiv -2 \ln \mathcal{L}$ by one unit. We also give the statistical significance $S$, computed as the square root of the difference between the value of $\chi^2$ for zero signal and the value at its minimum.

In Fig. 2 we show projections of $m_{EC}$ for both modes. The projections are made by applying a requirement on the individual event likelihood (computed without $m_{EC}$) to select the more signal-like events. The overlaid curves represent the ML fit PDF scaled to take into account the effect of the additional requirement.

For each measurement the supporting requirement-based analysis yielded compatible results with comparable, if somewhat larger, statistical errors.
Table 1: signal event yield with statistical uncertainty, detection efficiency ($\epsilon$, %), daughter branching fractions (%), significance $S$, and branching fraction result for each decay chain.

| Mode     | Signal yield | $\epsilon$ | $\prod B_i$ | $S$ | $B(\times10^{-6})$ (CL 90 %) |
|----------|--------------|-------------|-------------|-----|-------------------------------|
| $\eta K^{*0}$ | 21 $\pm$ 6  | 19.0        | 26.1        | 5.4 | $19.8^{+6.5}_{-5.6}$ $\pm$ 1.7 |
| $\eta K^{*+}$  | 14 $\pm$ 7  | 17.6        | 17.9        | 3.2 | $22.1^{+11.1}_{-9.2}$ $\pm$ 3.3 (33.9) |

Figure 2: $B$ candidate invariant mass for $B^0 \rightarrow \eta K^{*0}$ (left) and $B^+ \rightarrow \eta K^{*+}$ (right). Histograms represent data, and smooth curves represent the fit function.
5 Systematic studies

We have evaluated systematic errors, which are dominated by the PDF uncertainties (6–12%, depending on the decay mode). To determine these we varied parameters of the PDFs within their uncertainties and estimated the impact on the fit yield. This is the only additive systematic error; all others are multiplicative. Auxiliary studies lead to systematic errors of 1%, 2.5%, and 5% respectively for the imperfect simulation of track, photon, and $K^0_S$ efficiencies. These errors are summed linearly for the $B$ daughters. The $B$ production systematic error has been estimated in a separate study to be 1.6%. Published world averages \[10\] provide the $B$ daughter branching fraction uncertainties.

Systematic errors associated with the event selection are minimal given the generally loose requirements. We account explicitly for $|\cos\theta_T|$ (1%), for which we observe a nearly uniform distribution in the signal simulation. We also include errors of 4% due to the PID requirements.

6 Summary

We have found significant event yields in the decay $B \to \eta K^*$, as reported in Table 1. The final results are generally in agreement with those previously reported \[11\]. We confirm the rather larger than predicted \[12\] rate for $B \to \eta K^*$ obtained by the CLEO Collaboration \[11\]. The enhancement in $B \to \eta K^*$ could be due to constructively interfering internal penguin diagrams \[13\].

7 Acknowledgments

We are grateful for the extraordinary contributions of our PEP-II colleagues in achieving the excellent luminosity and machine conditions that have made this work possible. The collaborating institutions wish to thank SLAC for its support and the kind hospitality extended to them. This work is supported by the US Department of Energy and National Science Foundation, the Natural Sciences and Engineering Research Council (Canada), Institute of High Energy Physics (China), the Commissariat à l’Energie Atomique and Institut National de Physique Nucléaire et de Physique des Particules (France), the Bundesministerium für Bildung und Forschung (Germany), the Istituto Nazionale di Fisica Nucleare (Italy), the Research Council of Norway, the Ministry of Science and Technology of the Russian Federation, and the Particle Physics and Astronomy Research Council (United Kingdom). Individuals have received support from the Swiss National Science Foundation, the A. P. Sloan Foundation, the Research Corporation, and the Alexander von Humboldt Foundation.

References

[1] Charge conjugate states are implied throughout this paper.

[2] N. Cabibbo, Phys. Rev. Lett. 10, 531 (1963); M. Kobayashi and T. Maskawa, Prog. Th. Phys. 49, 652 (1973).

[3] The BABAR Collaboration, B. Aubert et al., SLAC-PUB-8569, hep-ex/0105044 (to appear in Nucl. Instr. and Methods ).

[4] PEP-II Conceptual Design Report, SLAC-R-418 (1993).
[5] The \textit{BABAR} Collaboration, B. Aubert \textit{et al.}, SLAC-PUB-8838, [arXiv:hep-ex/0105061], see Fig. 1(b).

(Submitted to Phys. Rev. Lett.)

[6] The \textit{BABAR} detector Monte Carlo simulation is based on GEANT:
R. Brun \textit{et al.}, CERN DD/EE/84-1.

[7] CLEO Collaboration, D.M. Asner \textit{et al.}, Phys. Rev. D \textbf{53}, 1039 (1996).

[8] T. Skwarnicki [Crystal Ball Collaboration], “A Study Of The Radiative Cascade Transitions Between The Upsilon-Prime And Upsilon Resonances,” DESY F31-86-02 (thesis, unpublished) (1986).

[9] ARGUS Collaboration, H. Albrecht \textit{et al.}, Phys. Lett. B \textbf{241} (1990) 278;
Phys. Lett. B \textbf{254} (1991) 288.

[10] Particle Data Group, D.E. Groom \textit{et al.}, Eur. Phys. Jour. C \textbf{15}, 1 (2000).

[11] CLEO Collaboration S.J. Richichi \textit{et al.}, Phys. Rev. Lett. \textbf{85}, 520 (2000);
CLEO CONF 99-12 (1999).

[12] A. Ali, G. Kramer, and C.D. Lü, Phys. Rev. D \textbf{58}, 094009 (1998);
Y. H. Chen \textit{et al.}, Phys. Rev. D \textbf{60}, 094014 (1999).

[13] H. J. Lipkin, Phys. Lett. B \textbf{254}, 247 (1991).