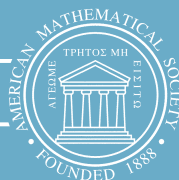

VOLUME 360 NUMBER 4



APRIL 2008

WHOLE NUMBER 875

TRANSACTIONS

OF THE

AMERICAN MATHEMATICAL SOCIETY

EDITED BY

Dan Abramovich
Alejandro Adem
Richard F. Bass
Mark Feighn
Robert Guralnick, Managing Editor
Lisa C. Jeffrey
Alexander Kleshchev
Steffen Lemp
William P. Minicozzi II
V. Kumar Murty
Alexander Nagel
Peter Polacik
Gustavo Ponce
Jonathan Rogawski
Dimitri Shlyakhtenko
Robert J. Stanton
John R. Stembridge
Daniel Tataru
Mina Teicher

PROVIDENCE, RHODE ISLAND USA

ISSN 0002-9947

Available electronically at
www.ams.org/tran/

Transactions of the American Mathematical Society

This journal is devoted entirely to research in pure and applied mathematics.

Submission information. See **Information for Authors** at the end of this issue.

Publisher Item Identifier. The Publisher Item Identifier (PII) appears at the top of the first page of each article published in this journal. This alphanumeric string of characters uniquely identifies each article and can be used for future cataloging, searching, and electronic retrieval.

Postings to the AMS website. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

Subscription information. *Transactions of the American Mathematical Society* is published monthly. Beginning in January 1996 *Transactions* is accessible from www.ams.org/journals/. Subscription prices for Volume 360 (2008) are as follows: for paper delivery, US\$1814 list, US\$1451 institutional member, US\$1633 corporate member; for electronic delivery, US\$1633 list, US\$1306 institutional member, US\$1470 corporate member. Upon request, subscribers to paper delivery of this journal are also entitled to receive electronic delivery. If ordering the paper version, add US\$49 for surface delivery outside the United States and India; US\$53 to India. Expedited delivery to destinations in North America is US\$79; elsewhere US\$144. For paper delivery a late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year.

Back number information. For back issues see www.ams.org/bookstore.

Subscriptions and orders should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904 USA. *All orders must be accompanied by payment.* Other correspondence should be addressed to 201 Charles Street, Providence, RI 02904-2294 USA.

Copying and reprinting. Material in this journal may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Acquisitions Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. Requests can also be made by e-mail to reprint-permission@ams.org.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

Transactions of the American Mathematical Society is published monthly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294 USA. Periodicals postage is paid at Providence, Rhode Island. Postmaster: Send address changes to *Transactions*, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

© 2008 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Mathematical Reviews*, *Zentralblatt MATH*, *Science Citation Index*[®], *Science Citation Index*TM-*Expanded*, *ISI Alerting Services*SM, *CompuMath Citation Index*[®], and *Current Contents*[®]/*Physical, Chemical & Earth Sciences*. This journal is archived in *Portico*.

Printed in the United States of America.

⊗ The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability.

TRANSACTIONS OF THE AMERICAN MATHEMATICAL SOCIETY

CONTENTS

Vol. 360, No. 4

Whole No. 875

April 2008

Ernst-Ulrich Gekeler, Frobenius distributions of Drinfeld modules over finite fields	1695
Jin Liang, Rainer Nagel, and Ti-Jun Xiao, Approximation theorems for the propagators of higher order abstract Cauchy problems	1723
Zhongwei Shen and Peihao Zhao, Uniform Sobolev inequalities and absolute continuity of periodic operators	1741
Peter A. Cholak and Leo A. Harrington, Extension theorems, orbits, and automorphisms of the computably enumerable sets	1759
Joel David Hamkins and Benedikt Löwe, The modal logic of forcing ..	1793
K. S. Chang, D. H. Cho, B. S. Kim, T. S. Song, and I. Yoo, Sequential Fourier-Feynman transform, convolution and first variation	1819
Siu-Hung Ng and Peter Schauenburg, Central invariants and higher indicators for semisimple quasi-Hopf algebras	1839
Feride Tıǧlay, The Cauchy problem and integrability of a modified Euler-Poisson equation	1861
Jon F. Carlson, Zongzhu Lin, and Daniel K. Nakano, Support varieties for modules over Chevalley groups and classical Lie algebras	1879
Otto Kerner and Jan Trlifaj, Constructing tilting modules	1907
Dessislava H. Kochloukova and Pavel A. Zalesskii, Profinite and pro- p completions of Poincaré duality groups of dimension 3	1927
Semyon Alesker and Joseph H. G. Fu, Theory of valuations on manifolds, III. Multiplicative structure in the general case	1951
Thomas Brady and Colum Watt, Non-crossing partition lattices in finite real reflection groups	1983
Keqin Feng and Chaoping Xing, A new construction of quantum error-correcting codes	2007
Luc Lapointe and Jennifer Morse, Quantum cohomology and the k -Schur basis	2021
Richard F. Bass and Takashi Kumagai, Symmetric Markov chains on \mathbb{Z}^d with unbounded range	2041
Henrik Shahgholian, Free boundary regularity close to initial state for parabolic obstacle problem	2077
Jonas Azzam, Michael A. Hall, and Robert S. Strichartz, Conformal energy, conformal Laplacian, and energy measures on the Sierpinski gasket	2089
Adam Harris and Krzysztof Wysocki, Branch structure of J -holomorphic curves near periodic orbits of a contact manifold	2131
Huyi Hu, Equilibriums of some non-Hölder potentials	2153
Lucien Guillou, Free lines for homeomorphisms of the open annulus	2191
Willem Veys and W. A. Zúñiga-Galindo, Zeta functions for analytic mappings, log-principalization of ideals, and Newton polyhedra	2205
Ronald G. Douglas and Gadadhar Misra, Equivalence of quotient Hilbert modules-II	2229

Editorial Information

To be published in the *Transactions*, a paper must be correct, new, nontrivial, and significant. Further, it must be well written and of interest to a substantial number of mathematicians. Piecemeal results, such as an inconclusive step toward an unproved major theorem or a minor variation on a known result, are in general not acceptable for publication.

Papers submitted to the *Transactions* should exceed 10 published journal pages in length. Shorter papers may be submitted to the *Proceedings of the American Mathematical Society*. Published pages are the same size as those generated in the style files provided for $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ or $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$.

Information on the backlog for this journal can be found on the AMS website starting from <http://www.ams.org/tran>.

In an effort to make articles available as quickly as possible, articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

A Consent to Publish and Copyright Agreement is required before a paper will be published in this journal. After a paper is accepted for publication, the Providence office will send a Consent to Publish and Copyright Agreement to all authors of the paper. By submitting a paper to this journal, authors certify that the results have not been submitted to nor are they under consideration for publication by another journal, conference proceedings, or similar publication.

Information for Authors

Initial submission. The AMS uses Centralized Manuscript Processing for initial submissions. Authors should submit a PDF file using the Initial Manuscript Submission form found at www.ams.org/cgi-bin/peertrack/submission.pl, or send one copy of the manuscript to the following address: Centralized Manuscript Processing, TRANSACTIONS OF THE AMS, 201 Charles Street, Providence, RI 02904-2294 USA. If a paper copy is being forwarded to the AMS, indicate that it is for *Transactions* and include the name of the corresponding author, contact information such as email address or mailing address, and the name of an appropriate Editor to review the paper (see the list of Editors below).

The first page of an article must consist of a *descriptive title*, followed by an *abstract* that summarizes the article in language suitable for workers in the general field (algebra, analysis, etc.). The *descriptive title* should be short, but informative; useless or vague phrases such as “some remarks about” or “concerning” should be avoided. The *abstract* should be at least one complete sentence, and at most 300 words. Included with the footnotes to the paper should be the 2000 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. The classifications are accessible from www.ams.org/msc/. The list of classifications is also available in print starting with the 1999 annual index of *Mathematical Reviews*. The Mathematics Subject Classification footnote may be followed by a list of *key words and phrases* describing the subject matter of the article and taken from it. Journal abbreviations used in bibliographies are listed in the latest *Mathematical Reviews* annual index. The series abbreviations are also accessible from www.ams.org/publications/. To help in preparing and verifying references, the AMS offers MR Lookup, a Reference Tool for Linking, at www.ams.org/mrlookup/.

Electronically prepared manuscripts. The AMS encourages electronically prepared manuscripts, with a strong preference for $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$. To this end, the Society has prepared $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ author packages for each AMS publication. Author packages include instructions for preparing electronic manuscripts, samples, and a style file that generates the particular design specifications of that publication series. Articles properly prepared using the $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ style file and the `\label` and `\ref` commands automatically enable extensive intra-document linking to the bibliography and other elements of the article for searching electronically on the Web. Because linking must often be added manually to electronically prepared manuscripts in other forms of $\mathcal{T}\mathcal{E}\mathcal{X}$, using $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ also reduces the amount of technical intervention once the files are received by the AMS. This results in fewer errors in processing and saves the author proofreading time. $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$

papers also move more efficiently through the production stream, helping to minimize publishing costs.

$\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ is the highly preferred format of $\mathcal{T}\mathcal{E}\mathcal{X}$, but author packages are also available in $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$. Those authors who make use of these style files from the beginning of the writing process will further reduce their own efforts. Manuscripts prepared electronically in $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ or plain $\mathcal{T}\mathcal{E}\mathcal{X}$ are normally not acceptable due to the high amount of technical time required to insure that the file will run properly through the AMS in-house production system. $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ users will find that $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ is the same as $\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ with additional commands to simplify the typesetting of mathematics, and users of plain $\mathcal{T}\mathcal{E}\mathcal{X}$ should have the foundation for learning $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$.

Authors may retrieve an author package from the AMS website starting from www.ams.org/tex/ or via FTP to [ftp.ams.org](ftp://ftp.ams.org) (login as `anonymous`, enter username as password, and type `cd pub/author-info`). The *AMS Author Handbook* and the *Instruction Manual* are available in PDF format following the author packages link from www.ams.org/tex/. The author package can also be obtained free of charge by sending email to tech-support@ams.org (Internet) or from the Publication Division, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. When requesting an author package, please specify $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{L}\mathcal{A}\mathcal{T}\mathcal{E}\mathcal{X}$ or $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\mathcal{T}\mathcal{E}\mathcal{X}$ and the publication in which your paper will appear. Please be sure to include your complete email address.

After acceptance. The final version of the electronic manuscript should be sent to the Providence office immediately after the paper has been accepted for publication. The author should also send the final version of the paper to the Editor, who will forward a copy to the Providence office. Accepted electronically prepared manuscripts can be submitted via the web at www.ams.org/submit-book-journal/, sent via email to pub-submit@ams.org (Internet), or sent on diskette to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. When sending a manuscript electronically via email or diskette, please be sure to include a message indicating in which publication the paper has been accepted. No corrections will be accepted electronically. Authors must mark their changes on their proof copies and return them to the Providence office. Complete instructions on how to send files are included in the author package.

Electronic graphics. Comprehensive instructions on preparing graphics are available starting from www.ams.org/jourhtml/authors.html. A few of the major requirements are given here.

Submit files for graphics as EPS (Encapsulated PostScript) files. This includes graphics originated via a graphics application as well as scanned photographs or other computer-generated images. If this is not possible, TIFF files are acceptable as long as they can be opened in Adobe Photoshop or Illustrator. No matter what method was used to produce the graphic, it is necessary to provide a paper copy to the AMS.

Authors using graphics packages for the creation of electronic art should also avoid the use of any lines thinner than 0.5 points in width. Many graphics packages allow the user to specify a “hairline” for a very thin line. Hairlines often look acceptable when proofed on a typical laser printer. However, when produced on a high-resolution laser imagesetter, hairlines become nearly invisible and will be lost entirely in the final printing process.

Screens should be set to values between 15% and 85%. Screens which fall outside of this range are too light or too dark to print correctly. Variations of screens within a graphic should be no less than 10%.

AMS policy on making changes to articles after posting. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue. To preserve the integrity of electronically published articles, once an article is individually posted to the AMS website but not yet in an issue, changes cannot be made in place in the paper. However, an “Added after posting” section may be added to the paper right before the References when there is a critical error in the content of the paper. The “Added after posting” section gives the author an opportunity to correct this type of critical error before the article is put into an issue for printing and before it is then

reposted with the issue. The “Added after posting” section remains a permanent part of the paper. The AMS does not keep author-related information, such as affiliation, current address, and email address, up to date after a paper is initially posted.

Once the article is assigned to an issue, even if the issue has not yet been posted to the AMS website, corrections may be made to the paper by submitting a traditional errata article. The errata article will appear in a future print issue and will link back and forth on the web to the original article online.

Secure manuscript tracking on the Web. Authors can track their manuscripts through the AMS journal production process using the personal AMS ID and Article ID printed in the upper right-hand corner of the Consent to Publish form sent to each author who publishes in AMS journals. Access to the tracking system is available from www.ams.org/mstrack/. An explanation of each production step is provided on the web through links from the manuscript tracking screen. Questions can be sent to tran-query@ams.org.

T_EX files available upon request. T_EX files are available upon request for authors by sending email to file-request@ams.org or by contacting the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. The request should include the title of the paper, the name(s) of the author(s), the name of the publication in which the paper has or will appear, and the volume and issue numbers if known. The T_EX file will be sent to the author making the request after the article goes to the printer. If the requestor can receive Internet email, please include the email address to which the file should be sent. Otherwise please indicate a diskette format and postal address to which a disk should be mailed. **Note:** Because T_EX production at the AMS sometimes requires extra fonts and macros that are not yet publicly available, T_EX files cannot be guaranteed to run through the author’s version of T_EX without errors. The AMS regrets that it cannot provide support to eliminate such errors in the author’s T_EX environment.

Inquiries. Any inquiries concerning a paper that has been accepted for publication that cannot be answered via the manuscript tracking system mentioned above should be sent to tran-query@ams.org or directly to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

Editors

The AMS uses Centralized Manuscript Processing for initial submissions to AMS journals. Authors should follow instructions listed on the Initial Submission page found at www.ams.org/tran/transubmit.html.

Algebra, ALEXANDER KLESHCHEV, Department of Mathematics, University of Oregon, Eugene, OR 97403-1222 USA; e-mail: ams@noether.uoregon.edu

Algebra and its applications, MINA TEICHER, Emmy Noether Research Institute for Mathematics, Bar-Ilan University, Ramat-Gan 52900, Israel; e-mail: teicher@macs.biu.ac.il, with cc to eni@macs.biu.ac.il

Algebraic geometry, DAN ABRAMOVICH, Department of Mathematics, Brown University, Box 1917, Providence, RI 02912 USA; e-mail: amsedit@math.brown.edu

Algebraic number theory, V. KUMAR MURTY, Department of Mathematics, University of Toronto, 100 St. George Street, Toronto, Ontario, Canada M5S 3G3; e-mail: murty@math.toronto.edu

Algebraic topology, ALEJANDRO ADEM, Department of Mathematics, University of British Columbia, Room 121, 1984 Mathematics Road, Vancouver, British Columbia, Canada V6T 1Z2; e-mail: transactions@math.ubc.ca

Combinatorics, JOHN R. STEMBRIDGE, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1043 USA; e-mail: jrs@umich.edu

Complex analysis and harmonic analysis, ALEXANDER NAGEL, Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706-1313 USA; e-mail: nagel@math.wisc.edu

Differential geometry and global analysis, LISA C. JEFFREY, Department of Mathematics, University of Toronto, Bahen Centre for Information Technology, 40 St. George Street 6th Floor, Toronto, Ontario, Canada M5S 2E4; e-mail: jeffrey@math.toronto.edu

Functional analysis and operator algebras, DIMITRI SHLYAKHTENKO, Department of Mathematics, University of California, Los Angeles, CA 90095 USA; e-mail: shlyakht@math.ucla.edu

Geometric analysis, WILLIAM P. MINICOZZI II, Department of Mathematics, Johns Hopkins University, 3400 N. Charles Street, Baltimore, MD 21218 USA; e-mail: trans@math.jhu.edu

Geometric topology, MARK FEIGHN, Department of Mathematics, Rutgers University, Newark, NJ 07102 USA; e-mail: feighn@andromeda.rutgers.edu

Harmonic analysis, representation theory, and Lie theory, ROBERT J. STANTON, Department of Mathematics, Ohio State University, 231 West 18th Avenue, Columbus, OH 43210-1174 USA; e-mail: stanton@math.ohio-state.edu

Logic, STEFFEN LEMPP, Department of Mathematics, University of Wisconsin, 480 Lincoln Drive, Madison, WI 53706-1388 USA; e-mail: lempp@math.wisc.edu

Number theory, JONATHAN ROGAWSKI, Department of Mathematics, University of California, Los Angeles, CA 90095 USA; e-mail: jonr@math.ucla.edu

Partial differential equations, GUSTAVO PONCE, Department of Mathematics, South Hall, Room 6607, University of California, Santa Barbara, CA 93106 USA; e-mail: ponce@math.ucsb.edu

Partial differential equations and dynamical systems, PETER POLACIK, School of Mathematics, University of Minnesota, Minneapolis, MN 55455 USA; e-mail: polacik@math.umn.edu

Probability and statistics, RICHARD F. BASS, Department of Mathematics, University of Connecticut, Storrs, CT 06269-3009 USA; e-mail: bass@math.uconn.edu

Real analysis and partial differential equations, DANIEL TATARU, Department of Mathematics, University of California, Berkeley, CA 94720 USA; e-mail: tataru@math.berkeley.edu

All other communications to the editors should be addressed to the Managing Editor, ROBERT GURALNICK, Department of Mathematics, University of Southern California, Los Angeles, CA 90089-1113 USA; e-mail: guralnic@math.usc.edu

MEMOIRS OF THE AMERICAN MATHEMATICAL SOCIETY

Memoirs is devoted to research in pure and applied mathematics of the same nature as *Transactions*. An issue consists of one or more separately bound research tracts for which the authors provide reproduction copy. Papers intended for *Memoirs* should normally be at least 80 pages in length. *Memoirs* has the same editorial committee as *Transactions*; authors may choose an Editor from the list above upon submission.

(Continued from back cover)

Lucien Guillou , Free lines for homeomorphisms of the open annulus	2191
Willem Veys and W. A. Zúñiga-Galindo , Zeta functions for analytic mappings, log-principalization of ideals, and Newton polyhedra	2205
Ronald G. Douglas and Gadadhar Misra , Equivalence of quotient Hilbert modules–II	2229

TRANSACTIONS OF THE AMERICAN MATHEMATICAL SOCIETY
 CONTENTS

Vol. 360, No. 4

Whole No. 875

April 2008

Ernst-Ulrich Gekeler, Frobenius distributions of Drinfeld modules over finite fields 1695

Jin Liang, Rainer Nagel, and Ti-Jun Xiao, Approximation theorems for the propagators of higher order abstract Cauchy problems 1723

Zhongwei Shen and Peihao Zhao, Uniform Sobolev inequalities and absolute continuity of periodic operators 1741

Peter A. Cholak and Leo A. Harrington, Extension theorems, orbits, and automorphisms of the computably enumerable sets 1759

Joel David Hamkins and Benedikt Löwe, The modal logic of forcing . 1793

K. S. Chang, D. H. Cho, B. S. Kim, T. S. Song, and I. Yoo, Sequential Fourier-Feynman transform, convolution and first variation 1819

Siu-Hung Ng and Peter Schauenburg, Central invariants and higher indicators for semisimple quasi-Hopf algebras 1839

Feride Tığlay, The Cauchy problem and integrability of a modified Euler-Poisson equation 1861

Jon F. Carlson, Zongzhu Lin, and Daniel K. Nakano, Support varieties for modules over Chevalley groups and classical Lie algebras 1879

Otto Kerner and Jan Trlifaj, Constructing tilting modules 1907

Dessislava H. Kochloukova and Pavel A. Zalesskii, Profinite and pro- p completions of Poincaré duality groups of dimension 3 1927

Semyon Alesker and Joseph H. G. Fu, Theory of valuations on manifolds, III. Multiplicative structure in the general case 1951

Thomas Brady and Colum Watt, Non-crossing partition lattices in finite real reflection groups 1983

Keqin Feng and Chaoping Xing, A new construction of quantum error-correcting codes 2007

Luc Lapointe and Jennifer Morse, Quantum cohomology and the k -Schur basis 2021

Richard F. Bass and Takashi Kumagai, Symmetric Markov chains on \mathbb{Z}^d with unbounded range 2041

Henrik Shahgholian, Free boundary regularity close to initial state for parabolic obstacle problem 2077

Jonas Azzam, Michael A. Hall, and Robert S. Strichartz, Conformal energy, conformal Laplacian, and energy measures on the Sierpinski gasket 2089

Adam Harris and Krzysztof Wysocki, Branch structure of J -holomorphic curves near periodic orbits of a contact manifold 2131

Huyi Hu, Equilibriums of some non-Hölder potentials 2153

(Continued on inside back cover)



0002-9947(200804)360:4;1-K