

---

VOLUME 31

NUMBER 2

DECEMBER 2018

---

# SUGAKU

EXPOSITIONS

ISSN 0898-9583 (print)  
ISSN 2473-585X (online)

---

A M E R I C A N M A T H E M A T I C A L S O C I E T Y

---

A Translation of

数 学



---

AMERICAN  
MATHEMATICAL  
SOCIETY

Providence, Rhode Island USA

# Sugaku Expositions

*A translation of the expository articles of*

# 数 学

© 編集・発行 東京都台東区台東 1-34-8 日本数学会

発 売 東京都千代田区一ツ橋 2-5-5 株式会社 岩 波 書 店  
(振替 00160-26240 番)

*Sugaku Expositions* consists of translations of the expository articles in *Sūgaku* and is published by arrangement with Iwanami Shoten Publishers, Tokyo, and the Mathematical Society of Japan.

**Subscription Information.** *Sugaku Expositions* is published twice annually. Subscription prices for Volume 31 (2018) are as follows:

**Paper format with free electronic access:** US\$285 list; US\$228 institutional member; US\$171 individual member. **Electronic access only:** US\$271 list; US\$216.80 institutional member; US \$162.60 individual member.

For more information, contact Customer Services at [cust-serv@ams.org](mailto:cust-serv@ams.org).

**Back Number Information.** For back issues see [www.ams.org/backvols](http://www.ams.org/backvols).

Subscriptions and orders for publications of the American Mathematical Society should be addressed to 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 02904-2213 USA.

**Copying and Reprinting.** Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Requests for permission to reuse portions of AMS publication content are handled by the Copyright Clearance Center.

For more information, please visit [www.ams.org/publications/pubpermissions](http://www.ams.org/publications/pubpermissions).

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.)

---

*Sugaku Expositions* is published by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213 USA, and is mailed from Providence, Rhode Island. Postmaster: Send address changes to Sugaku Expositions, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA.

© 2018 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Mathematical Reviews* and *Zentralblatt MATH*.

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.

10 9 8 7 6 5 4 3 2 1      23 22 21 20 19 18

SUGAKU EXPOSITIONS  
CONTENTS

Vol. 31, No. 2

December 2018

<b>Masato Kikuchi</b> , <a href="#">Martingales and function spaces</a> .....	117
<b>Noboru Okazawa</b> , <a href="#">Operator theory in the complex Ginzburg-Landau equation</a> .....	143
<b>Tatsuo Nishitani</b> , <a href="#">The Cauchy problem for differential operators with double characteristics</a> .....	169
<b>Yukinobu Toda</b> , <a href="#">Curve counting theories on Calabi-Yau 3-folds: Approach via stability conditions on derived categories</a> .....	199
<b>Daisuke Furihata and Takayasu Matsuo</b> , <a href="#">Discrete variational derivative method—A structure-preserving numerical method for partial differential equations</a> .....	231

## INDEX TO VOLUME 31 (2018)

- Furihata, Daisuke, and Takayasu Matsuo. *Discrete variational derivative method—A structure-preserving numerical method for partial differential equations*, 231
- Kikuchi, Masato. *Martingales and function spaces*, 117
- Matsuo, Takayasu. *See* Furihata, Daisuke
- Nishitani, Tatsuo. *The Cauchy problem for differential operators with double characteristics*, 169
- Okazawa, Noboru. *Operator theory in the complex Ginzburg-Landau equation*, 143
- Takagi, Shunsuke, and Kei-ichi Watanabe. *F-singularities: applications of characteristic  $p$  methods to singularity theory*, 1
- Terao, Hiroaki, and Masahiko Yoshinaga. *Recent topics of arrangements of hyperplanes*, 43
- Toda, Yukinobu. *Curve counting theories on Calabi-Yau 3-folds: Approach via stability conditions on derived categories*, 199
- Tsujii, Masato. *Geodesic flows on negatively curved manifolds and the semi-classical zeta function*, 69
- Ueki, Naomasa. *Stochastic analysis and random Schrödinger operators*, 93
- Watanabe, Kei-ichi. *See* Takagi, Shunsuke
- Yoshinaga, Masahiko. *See* Terao, Hiroaki

---

VOLUME 31

2018

---

# SUGAKU

ISSN 0898-9583 (print)  
ISSN 2473-585X (online)

## EXPOSITIONS

---

A M E R I C A N M A T H E M A T I C A L S O C I E T Y

---

A Translation of

数 学



AMERICAN  
MATHEMATICAL  
SOCIETY

Providence, Rhode Island USA

# Sugaku Expositions

*A translation of the expository articles of*

# 数 学

© 編集・発行 東京都台東区台東 1-34-8 日本数学会

発 売 東京都千代田区一ツ橋 2-5-5 株式会社 岩 波 書 店  
(振替 00160-26240 番)

*Sugaku Expositions* consists of translations of the expository articles in *Sūgaku* and is published by arrangement with Iwanami Shoten Publishers, Tokyo, and the Mathematical Society of Japan.

**Subscription Information.** *Sugaku Expositions* is published twice annually. Subscription prices for Volume 31 (2018) are as follows:

**Paper format with free electronic access:** US\$285 list; US\$228 institutional member; US\$171 individual member. **Electronic access only:** US\$271 list; US\$216.80 institutional member; US \$162.60 individual member.

For more information, contact Customer Services at [cust-serv@ams.org](mailto:cust-serv@ams.org).

**Back Number Information.** For back issues see [www.ams.org/backvols](http://www.ams.org/backvols).

Subscriptions and orders for publications of the American Mathematical Society should be addressed to 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 02904-2213 USA.

**Copying and Reprinting.** Individual readers of this publication, and nonprofit libraries acting for them, are permitted to make fair use of the material, such as to copy an article for use in teaching or research. Permission is granted to quote brief passages from this publication in reviews, provided the customary acknowledgment of the source is given.

Republication, systematic copying, or multiple reproduction of any material in this publication is permitted only under license from the American Mathematical Society. Requests for permission to reuse portions of AMS publication content are handled by the Copyright Clearance Center.

For more information, please visit [www.ams.org/publications/pubpermissions](http://www.ams.org/publications/pubpermissions).

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.)

---

*Sugaku Expositions* is published by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213 USA, and is mailed from Providence, Rhode Island. Postmaster: Send address changes to Sugaku Expositions, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2213 USA.

© 2018 by the American Mathematical Society. All rights reserved.

This journal is indexed in *Mathematical Reviews* and *Zentralblatt MATH*.

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.

10 9 8 7 6 5 4 3 2 1      23 22 21 20 19 18

# SUGAKU EXPOSITIONS

## CONTENTS

Vol. 31, No. 1

June 2018

<b>Shunsuke Takagi and Kei-ichi Watanabe</b> , <i><math>F</math>-singularities: applications of characteristic <math>p</math> methods to singularity theory</i> .....	1
<b>Hiroaki Terao and Masahiko Yoshinaga</b> , <i>Recent topics of arrangements of hyperplanes</i> .....	43
<b>Masato Tsujii</b> , <i>Geodesic flows on negatively curved manifolds and the semi-classical zeta function</i> .....	69
<b>Naomasa Ueki</b> , <i>Stochastic analysis and random Schrödinger operators</i> ...	93

Vol. 31, No. 2

December 2018

<b>Masato Kikuchi</b> , <i>Martingales and function spaces</i> .....	117
<b>Noboru Okazawa</b> , <i>Operator theory in the complex Ginzburg-Landau equation</i> .....	143
<b>Tatsuo Nishitani</b> , <i>The Cauchy problem for differential operators with double characteristics</i> .....	169
<b>Yukinobu Toda</b> , <i>Curve counting theories on Calabi-Yau 3-folds: Approach via stability conditions on derived categories</i> .....	199
<b>Daisuke Furihata and Takayasu Matsuo</b> , <i>Discrete variational derivative method—A structure-preserving numerical method for partial differential equations</i> .....	231





SUGAKU EXPOSITIONS  
CONTENTS

Vol. 31, No. 2

December 2018

<b>Masato Kikuchi</b> , Martingales and function spaces .....	117
<b>Noboru Okazawa</b> , Operator theory in the complex Ginzburg-Landau equation .....	143
<b>Tatsuo Nishitani</b> , The Cauchy problem for differential operators with double characteristics .....	169
<b>Yukinobu Toda</b> , Curve counting theories on Calabi-Yau 3-folds: Approach via stability conditions on derived categories .....	199
<b>Daisuke Furihata and Takayasu Matsuo</b> , Discrete variational derivative method—A structure-preserving numerical method for partial differential equations .....	231



0898-9583(201812)31:2\*;1-7

