

Physics–Uspekhi

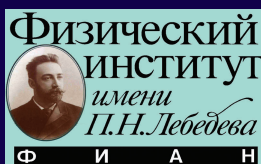
Advances in Physical Sciences



June 2020

Volume 63, Number 6

Translation of the Russian journal
Успехи физических наук, Uspekhi Fizicheskikh Nauk
June 2020, Volume 190, No. 6



Turpion

IOP Publishing



PHYSICS- USPEKHI

ISSN 1063-7869 (Print)
ISSN 1468-4780 (Online)

CODEN: PHUSEY

Uspekhi Fizicheskikh Nauk

Editor Valery A Rubakov
Associate Editors Lev P Pitaevskii, Oleg V Rudenko
Managing Editor Maria S Aksent'eva
Advisory Board Evgenii B Aleksandrov
Fazly I Ataullakhanov
Yurii V Gulyaev
Sergei P Denisov
Lev M Zelenyi
Aleksandr A Kaplyanskii
Olga A Kocharovskaya
Gennadii N Kulipanov
Aleksandr G Litvak
Gennadii A Mesyats
Rashid A Sunyaev
Vladimir E Fortov
Aleksei R Khokhlov
Anatolii M Cherepashchuk

Editorial Board

Petr I Arseev
Vasily S Beskin
Aleksandr E Bondar'
Vadim V Brazhkin
Sergei V Bulanov
Mikhail A Vasil'ev
Mikhail I Vysotskii
Igor M Dremin
Aleksei M Zheltikov
Genrikh R Ivanitskii
Dmitrii I Kazakov
Vitalii V Kveder
Nikolai N Kolachevskii
Zakhar'ii F Krasil'nik
Evgenii A Kuznetsov
Sergei A Nikitov
Vladimir F Obraztsov
Pavel N Pakhlov
Konstantin A Postnov
Vladimir I Ritus
Grigorii I Rubtsov
Mikhail V Sadvoskii
Aleksandr M Sergeev
Boris M Smirnov
Robert A Suris
Dmitrii R Khokhlov
Maria V Chekhova
Evgenii M Churazov

Scientific and Staff Editors

MS Aksent'eva, EA Frimer, TB Larionova,
TP Romanova, EV Zakharova

Uspekhi Fizicheskikh Nauk (Успехи Физических Наук, www.ufn.ru) publishes reviews of the current state of the most topical problems in physics and in associated fields under the general headings: reviews of topical problems, physics of our days, instruments and methods of investigation, methodological notes, from the history of physics, conferences and symposia, personalia, physics news on the Internet, and bibliography. The journal was founded in 1918 and is published monthly.

Physics – Uspekhi

Scientific Editors MS Aksent'eva, VL Derbov, AM Semikhatov
English Language Editor K Franchuk
Desk Editors AV Bobkov, NV Gribkova, OV Morgunova

Physics–Uspekhi (Advances in Physical Sciences) is the English edition of the Russian monthly journal *Uspekhi Fizicheskikh Nauk*. Translation into English started with Russian volume 66. From 1958 until 1992 the journal was published by American Institute of Physics under the title *Soviet Physics–Uspekhi* and in 1993 under its current title *Physics – Uspekhi*. Since 1994 *Physics – Uspekhi* has been published jointly by Uspekhi Fizicheskikh Nauk and Turpion Ltd. From the beginning of 1996 *Physics – Uspekhi* is being translated, typeset and edited in Moscow by Uspekhi Fizicheskikh Nauk (UFN), from 2009 published by Uspekhi Fizicheskikh Nauk, Moscow, printed by Page Bros, Norwich, UK.

Institutional subscription information (volume 63, 2020, monthly) For all countries, except the United States, Canada, Central and South America, the subscription rates are: Print + Online (1958 – 2020) £ 1992; Online only (1958 – 2020) £ 1792. Delivery is by air-speeded mail from the UK.

Orders, back issues, change of address to: Physics–Uspekhi, Journals Subscription Fulfilment, IOP Publishing, Temple Circus, Temple Way, Bristol BS1 6HG, United Kingdom

For the United States, Canada, Central and South America, the subscription rates are: Print + Online (1958 – 2020) US \$3585; Online only (1958 – 2020) US \$ 3225. Delivery is by transatlantic airfreight and onward mailing. **United States Postal Identification Statement** *Physics – Uspekhi*, volume 63, published monthly. Periodicals Postage Paid at Continental Station, PA and additional mailing offices. POSTMASTER: Send orders, address changes to *Physics – Uspekhi*, IOP Publishing, PO Box 320, Congers, NY 10920-0320, USA.

Online services: Since 2008 electronic access to the journal content is hosted by IOP Publishing. All subscriptions to the journal include electronic access dating from the first English translation volume. The electronic version of the journal is available at <http://iopscience.org/phu>. All questions regarding online access should be sent to customer services at customerservices@iopublishing.org or custserv@turpion.ru

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form, or by any means, electronic, mechanical, photographic, recording, or otherwise, without the prior permission of *Uspekhi Fizicheskikh Nauk*.

Editorial Office: P N Lebedev Physical Institute, RAS, Leninskii prospekt 53, 119991 Moscow, Russian Federation
Tel. (7-499) 132 62 65, (7-499) 190 34 52
Tel./Fax (7-499) 190 42 44. E-mail: ufn@ufn.ru

Contents

| | | |
|-----|---|-----|
| 561 | Ultrahard nanomaterials: myths and reality V V Brazhkin | 523 |
| 585 | Mechanisms and kinetics of gravity separation of granular materials V N Dolgunin, A N Kudi, M A Tuev | 545 |
| 605 | Study of exoplanets by spectroscopic methods V E Panchuk, Yu Yu Balega, V G Klochkova, M E Sachkov | 562 |
| 627 | Silhouettes of invisible black holes V I Dokuchaev, N O Nazarova | 583 |
| 648 | Generalization of the k coefficient method in relativity to an arbitrary angle between the velocity of an observer (source) and the direction of the light ray from (to) a faraway source (observer) at rest V I Ritus | 601 |
| 658 | Identity of the mechanisms of Weibel and Alfvén-cyclotron plasma instabilities A S Dzarakhokhova, N P Zaretskii, A V Maksimychyev, L I Menshikov, P L Menshikov | 611 |
| 664 | Wormholes with entrances close to each other N S Kardashev, I D Novikov, S V Repin | 617 |
| 669 | In memory of Nikolai Semenovich Kardashev | 622 |
| 671 | Physics news on the Internet Yu N Eroshenko | 625 |

◇ ◇ ◇

In the next issue

Topological insulators based on HgTe

Z D Kvon, D A Kozlov, E B Olshanetsky,
G M Gusev, N N Mikhailov, S A Dvoretzky

Field emission from carbon nanostructures: models and experiment

E D Eidelman, A V Arkhipov

Pairwise interatomic interaction in alloys

Yu I Ustinovshchikov

*Structure and dynamics of concentrated mesoscale vortices
in planetary atmospheres*

O G Onishchenko, O A Pokhotelov, N M Astafeva, W Horton, V N Fedun

Photon entanglement for life-science imaging:

rethinking the limits of the possible

A M Zheltikov, M O Scully

High resolution terahertz spectroscopy for analytical applications

V L Vaks, V A Anfertev, V Yu Balakirev, S A Basov, E G Domracheva,
A V Illyuk, P V Kupriyanov, S I Pripolzin, M B Chernyaeva

*Was Sommerfeld wrong? (To the history of the appearance of spin
in relativistic wave equations)*

S V Petrov

Personalia

Physics news on the Internet

