PHYSICAL REVIEW A THIRD SERIES, VOLUME 112, NUMBER 6 DECEMBER 2025

$\mathbf{A}^2$-robust superradiant phase transition in hybrid qubit-cavity optomechanics *(8 pages)* . . . . . 063727
Gang Liu and Wei Xiong

Floquet-engineered tunable and nonreciprocal couplings in waveguide QED *(10 pages)* . . . . . 063728
Yuan Liu and Linhan Lin

Control of superradiation bursts arising from a nonlinear optical cavity containing a closely packed chain of atoms *(9 pages)* . . . . . 063729
F. Lotfi and M. M. Golshan

Exponentially enhanced tripartite coupling in quantum nonlinear magnonics *(9 pages)* . . . . . 063730
Xue-Chun Chen, Zi-Jie Wang, Sheng-Bo Zheng, Jiaojiao Chen, and Wei Xiong

## COMMENTS

Comment on "Consequences of the single-pair measurement of the Bell parameter" *(3 pages)* . . . . . 066201
Marian Kupczynski

Comment on "Consequences of the single-pair measurement of the Bell parameter" *(2 pages)* . . . . . 066202
Justo Pastor Lambare

Reply to "Comments on 'Consequences of the single-pair measurement of the Bell parameter' " *(3 pages)* . . . . . 066203
Marco Genovese and Fabrizio Piacentini

## ERRATA

Erratum: Landé $g$-factor measurements for the $5d6s\ ^3D_2$ hyperfine levels of $^{176}Lu^+$ [Phys. Rev. A **112**, 032808 (2025)] *(1 page)* . . . . . 069901(E)
Qi Zhao, M. D. K. Lee, Qin Qichen, Zhao Zhang, N. Jayjong, K. J. Arnold, and M. D. Barrett

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Tunable single-photon scattering and bound states via the magnonic Barnett effect in giant atom-waveguide QED *(11 pages)* . . . . . 063711
Shi-Qi Gan, Guoqing Tian, Zi-Hao Li, and Xin-You Lü

Certification of stellar ranks of quantum states of light with a pair of click detectors *(11 pages)* . . . . . 063712
Jaromír Fiurášek

Quantum statistics of single-mode radiation emitted by superradiant Dicke states *(8 pages)* . . . . . 063713
Anirudh Yadav and D. D. Yavuz

Spatial correlations in four-wave mixing with structured light *(15 pages)* . . . . . 063714
M. R. L. da Motta and S. S. Vianna

Tunable coherent and dissipative light-matter interactions enabled by chiral exceptional points of a microcavity *(12 pages)* . . . . . 063715
Yu-Wei Lu

Circular-beam approximation for quantum channels in a turbulent atmosphere *(17 pages)* . . . . . 063716
I. Pechonkin, M. Klen, and A. A. Semenov

Generation of entanglement between bright light fields via spontaneous decay-induced quantum interference *(6 pages)* . . . . . 063717
Xihua Yang, Mingfei Cheng, Xiaodong Zeng, Zhenghong Li, and Min Xiao

Cavity QED from few to many emitters: Energy levels and emission spectra from weak to deep-strong coupling *(23 pages)* . . . . . 063718
Andrea Zappalá, Alberto Mercurio, Daniele Lamberto, Samuel Napoli, Omar Di Stefano, and Salvatore Savasta

Photon-number entanglement from cascaded parametric down-conversion *(7 pages)* . . . . . 063719
Shu-Tian Xue (薛舒天), He Jiang (姜贺), Jing Wang (王晶), Zhi-Cheng Ren (任志成), Xi-Lin Wang (汪喜林), and Hui-Tian Wang (王慧田)

Coherent phase control of orbital-angular-momentum light-induced torque in a double-tripod atom-light coupling scheme *(10 pages)* . . . . . 063720
Hamid R. Hamedi, Viačeslav Kudriašov, Mažena Mackoit Sinkevičienė, and Julius Ruseckas

Generation of generalized two-mode Schrödinger cat state through strong ground-state coupling *(11 pages)* . . . . . 063721
Xufeng Jiang, Lituo Shen, and Zhenbiao Yang

Quantum complementarity *ad infinitum*: Switching higher-order coherence from infinity to zero *(14 pages)* . . . . . 063723
Arash Azizi

Third-quantized master equations as a classical Ornstein-Uhlenbeck process *(19 pages)* . . . . . 063724
Léonce Dupays

Photon-resolved Floquet theory approach to spectroscopic quantum sensing *(29 pages)* . . . . . 063725
Georg Engelhardt, Konstantin Dorfman, and Zhedong Zhang

Doppler-free Rydberg spectroscopy in a warm vapor *(7 pages)* . . . . . 063726
Jeremy Glick, Brielle E. Anderson, T. Nathan Nunley, Josiah Bingaman, Jian Jun Liu, David H. Meyer, and Paul Kunz

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Asynchronous vector solitons with tailored oscillation periods in mode-locked fiber lasers *(6 pages)* . . . . . 063532
Yue Yu, Xiao-Tian Xu, Xiankun Yao, and Wen-Li Yang

Parametric instabilities and mode coupling in oscillating spherical cavities: Theoretical framework *(11 pages)* . . . 063533
C. R. Singleton

Strong electric-field gradient in a nested plasmonic nanocavity for multipolar Raman spectroscopy *(9 pages)* . . . . 063534
Chenyang Kong, Yueweiying Wang, Xiaoshuang Tian, Feng Gao, Fanfan Lu, Ting Mei, and Wending Zhang

Strongly coupled photonic molecules as doubly coupled oscillators *(24 pages)* . . . . . 063535
Kevin C. Smith, Austin G. Nixon, and David J. Masiello

Theory of quantum spin Hall topological lasers *(15 pages)* . . . . . 063536
A. Muñoz de las Heras and I. Carusotto

High-order Mie resonance and transient field enhancement in laser-driven plasma nanoshells *(5 pages)* . . . . . 063537
Xiaohui Gao

**Quantum optics**

Engineering of maximally entangled orbital angular momentum states via path identity *(15 pages)* . . . . . 063701
Richard Bernecker, Baghdasar Baghdasaryan, and Stephan Fritzsche

Theory of multiqubit superradiance in a waveguide in the presence of finite delay times and two quantum excitations *(14 pages)* . . . . . 063702
Sofia Arranz Regidor, Franco Nori, and Stephen Hughes

Enhanced bundle emission of squeezed photons using parametric amplification *(10 pages)* . . . . . 063703
Zhicai Chen, Chengdeng Gou, Xiangming Hu, Deyi Kong, and Fei Wang

Non-Markovian dynamics of a driven three-level giant atom coupled to a semi-infinite waveguide via complex couplings *(28 pages)* . . . . . 063704
S. J. Sun, Z. Y. Li, C. Cui, Shuang Xu, and H. Z. Shen

Probing the non-Hermitian skin effect via the cavity transmission spectrum *(10 pages)* . . . . . 063705
Yu-Bo Liang, Chenyang Wang, Zi-Jian Lin, Ge Song, Jabir Hakami, Jingping Xu, and Ya-Ping Yang

Strong cubic phase shifts on the photonic vacuum state *(6 pages)* . . . . . 063706
Hao Jeng, Lorcán O. Conlon, Ping Koy Lam, and Syed M. Assad

Loss of integrability in a system with two-photon interactions *(16 pages)* . . . . . 063707
Fabrizio Ramírez, David Villaseñor, Viani S. Morales-Guzmán, Darly Y. Castro, and Jorge G. Hirsch

Broadband pulsed quadrature measurements with calorimeters *(6 pages)* . . . . . 063708
Ezad Shojaee, James R. van Meter, Karl Mayer, Scott Glancy, and Emanuel Knill

Ultrafast all-optical modulation of spatially structured photons *(13 pages)* . . . . . 063709
Alicia Sit, Frédéric Bouchard, Nicolas Couture, Duncan England, Guillaume Thekkadath, Philip J. Bustard, and Benjamin Sussman

Controllable single-photon wave-packet scattering in a two-dimensional resonator array by a giant atom *(16 pages)* . . . . . 063710
Weijun Cheng, Zhihai Wang, and Yu-xi Liu

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Description of partially coherent light beams using thermodynamic principles *(17 pages)* . . . . . 063516
Gabrielle Vaz, Marcio H. G. de Miranda, Ernesto P. Raposo, and Anderson M. Amaral

Parity-time-symmetry-induced Janus bound states in the continuum and rings of lasing threshold modes *(11 pages)* . . . . . 063517
Qianju Song, Zao Yi, Hong Xiang, and Dezhuan Han

Structured electromagnetic pulses with temporally knotted polarization *(6 pages)* . . . . . 063518
N. N. Rosanov and S. V. Fedorov

Coherence-independent non-Hermitian topological filters *(7 pages)* . . . . . 063519
Vinzenz Zimmermann, Amin Hashemi, Kurt Busch, Andrea Blanco-Redondo, and Armando Perez-Leija

Dispersive-wave-assisted sideband self-injection locking of soliton microcombs *(11 pages)* . . . . . 063520
Zhengyi Li and Fuchuan Lei

Threshold behavior in quantum-dot nanolasers: Effects of inhomogeneous broadening *(15 pages)* . . . . . 063521
Giampaolo D'Alessandro, Gian Luca Lippi, and Francesco Papoff

Purcell enhancement and suppression in laser cooling of $Yb^{3+}$:YLF nanocrystals in a Fabry-Pérot microcavity *(6 pages)* . . . . . 063522
Lucas Mendicino, Franco Mayo, Christian Schmiegelow, and Augusto Roncaglia

Unified quadruple-coupled model for terahertz quantum cascade lasers *(15 pages)* . . . . . 063523
Jin Zhu, Ke Yang, Tianyang Jiang, Mingjun Xia, and Deng Yuan

Structure function as a robust alternative to the correlation function in photon-count analysis *(10 pages)* . . . . . 063524
Abraham de J. Aguilar-Uribe, Carlos A. García-Cadena, Jair Bocanegra-Flores, and Luis F. Rojas-Ochoa

Ultrathin spiral microtube cavities for enhanced free-space coupling *(10 pages)* . . . . . 063525
Xiaoyan Zhang, Xiaoyu Wang, Xiaoyi Wu, Jiawei Wang, Libo Ma, and Yin Yin

Controllable switching of platicon propagation direction in normal-dispersion photonic-crystal microresonators *(11 pages)* . . . . . 063526
Valery E. Lobanov, Olga V. Borovkova, Artem E. Shitikov, Igor A. Bilenko, and Dmitry A. Chermoshentsev

Robustness of the beam-self-cleaning effect in graded-index multimode fibers *(9 pages)* . . . . . 063527
Yuhui Chao, Ping Fang, and Zhenming Yu

Resonances in Ge disk lattices on Si at telecommunication wavelengths *(10 pages)* . . . . . 063528
A. A. Shklyaev, D. E. Utkin, V. A. Zinovyev, S. A. Rudin, A. F. Zinovieva, A. V. Nenashev, N. A. Tashkeev, and S. L. Veber

Flexibly regulating dissipative optical soliton molecules via intracavity additional phase bias *(11 pages)* . . . . . 063529
Huiting Tang, Renlai Zhou, Wenbin Luo, Encai Ji, and Ye Li

Low-exposure high-quality multimodal speckle x-ray imaging via an intrinsic gradient-flow approach *(9 pages)* . . . . . 063530
Jayvan Liu, Samantha J. Alloo, Max Langer, and Konstantin M. Pavlov

Two-dimensional asymmetric diffraction induced by vortex light in quantum-dot-molecule systems under spontaneously generated coherence *(11 pages)* . . . . . 063531
Yiming Xu, Yiming Zhang, Shenwei Li, Leyu Li, Zhiwei Men, and Aijun Li

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).
The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

PHYSICAL REVIEW A THIRD SERIES, VOLUME 112, NUMBER 6 DECEMBER 2025

**Photonics, nonlinear optics, and optomechanics**

Keldysh parameter for laser-nucleus interactions *(17 pages)* . . . . . 063501
A. M. Zheltikov

Ultrabroadband supercontinuum generation with low energy consumption on dispersion-engineered lithium-niobate-on-insulator waveguides *(7 pages)* . . . . . 063502
Shanshan Cheng, Kun Yuan, Chenyu Wang, Mengwen Chen, Zikang Wang, Zhilin Ye, Ji Tang, Zhong Yan, Zhijun Yin, Xiaoshun Jiang, Xiao-Hui Tian, Kunpeng Jia, Zhenlin Wang, Shi-ning Zhu, and Zhenda Xie

Three-period evolution in a photonic Floquet extended Su-Schrieffer-Heeger waveguide array *(12 pages)* . . . . . 063503
Changsen Li, Yujie Zhou, Xiumei Wang, and Xingping Zhou

Exact modes, hybridization, and polarization rotation of electromagnetic fields propagating in a topological insulating slab *(32 pages)* . . . . . 063504
Sebastián Filipini, Mauro Cambiaso, Alberto Martín-Ruiz, and Luis F. Urrutia

Soliton number as a critical degree of freedom for high-efficiency Kerr soliton crystals in microresonators *(7 pages)* . . . . . 063505
Chenhong Li, Kangqi Liu, Mingfei Qu, Weihang Zhu, Yuan Wei, and Songbai Kang

Scattering modeling by a nonlinear slab: Exact solution of the full vector problem *(20 pages)* . . . . . 063506
Jérémy Itier, Gilles Renversez, and Frédéric Zolla

Etchless lithium niobate metasurfaces for enhanced second-harmonic generation via Fabry-Pérot bound states in the continuum *(9 pages)* . . . . . 063507
Huifu Qiu, Xu Tu, Meibao Qin, Feng Wu, Tingting Liu, and Shuyuan Xiao

Diamagnetic microchip traps for levitated nanoparticle entanglement experiments *(12 pages)* . . . . . 063508
Shafaq Gulzar Elahi, Martine Schut, Andrew Dana, Alexey Grinin, Sougato Bose, Anupam Mazumdar, and Andrew Geraci

Experimental proposal of a mode sorter for vector vortex beams of arbitrary order *(7 pages)* . . . . . 063509
P. Schneider Lacerda, L. Marques Fagundes, and R. Medeiros de Araújo

Optical Ising spin-glass simulator with tunable short-range couplings *(7 pages)* . . . . . 063510
Louis Delloye, Gianni Jacucci, Raj Pandya, Davide Pierangeli, Claudio Conti, and Sylvain Gigan

Theory of dispersive shock waves induced by the Raman effect in optical fibers *(9 pages)* . . . . . 063511
D. V. Shaykin and A. M. Kamchatnov

Proof-of-principle experiment for the dark-field detection concept for measuring vacuum birefringence *(10 pages)* . . . . . 063512
Michal Šmíd *et al.*

Polarization-independent helical dichroism via surface lattice resonance of plasmonic helices *(10 pages)* . . . . . 063513
Mengyuan He, Xuefen Kan, Cheng Yin, Qilin Jin, Qiubo Ye, Xiaobin Wang, and Jian Wu

Geometric spin Hall effect of spatiotemporal optical vortices *(6 pages)* . . . . . 063514
Chaokai Yang, Weifeng Ding, and Zhaoying Wang

Visualized geometric phase of caustic geometric beams *(13 pages)* . . . . . 063515
Haiyang Li and Yijie Shen

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Critical exponent of dynamical quantum phase transitions in the one-dimensional Bose-Hubbard model in the strongly interacting limit *(6 pages)* . . . . . 063307
Jia Li (李佳) and Yajiang Hao (郝亚江)

Symmetry oscillation sensitivity to SU(2)-symmetry breaking in quantum mixtures *(12 pages)* . . . . . 063308
S. Musolino, M. Albert, P. Vignolo, and A. Minguzzi

Universal momentum tail of identical one-dimensional anyons with two-body interactions *(16 pages)* . . . . . 063309
Raúl Hidalgo-Sacoto, Thomas Busch, and D. Blume

Two identical one-dimensional anyons with zero-range interactions: Exchange statistics, scattering theory, and anyon-anyon mapping *(16 pages)* . . . . . 063310
Raúl Hidalgo-Sacoto, Thomas Busch, and D. Blume

Anomalous Doppler effect in two-component Bose-Einstein condensates *(7 pages)* . . . . . 063311
Tomasz Zawiślak, Sandro Stringari, and Alessio Recati

Universal properties and dynamical bosonization of strongly interacting one-dimensional anyons *(16 pages)* . . . . . 063312
Ovidiu I. Pâţu

Quasiparticle properties of long-range impurities in a Bose condensate *(15 pages)* . . . . . 063313
T. Alper Yoğurt and Matthew T. Eiles

Generalized pulse design in Floquet engineering: Application to interacting spin systems *(15 pages)* . . . . . 063314
Ryan Scott, Bryce Gadway, and V. W. Scarola

Few-body bound states of bosonic mixtures in two-dimensional optical lattices *(10 pages)* . . . . . 063315
Matias Volante-Abovich, Felipe Isaule, and Luis Morales-Molina

Many-body physics from spin-phonon coupling in Rydberg-atom arrays *(9 pages)* . . . . . 063316
Shuo Zhang, Langxuan Chen, and Pengfei Zhang

Quantum diatomic chain: A supersolid structure in a three-component Bose mixture *(10 pages)* . . . . . 063317
Francesco Ancilotto

Effective interactions in quasi-one-dimensional dipolar quantum gases *(8 pages)* . . . . . 063318
Michał Zdziennicki, Mateusz Ślusarczyk, Krzysztof Pawłowski, and Krzysztof Jachymski

Trion ordering in the attractive three-color Hubbard model on a $\pi$-flux square lattice *(10 pages)* . . . . . 063319
Xiang Li, Yumeng Li, Quan Fu, and Yu Wang

Confined few-particle systems beyond mean-field theory adopting Gaussian-type orbitals and Morse interparticle interaction *(14 pages)* . . . . . 063320
Matee ur Rehman, Paul Winter, Fabio Revuelta, and Alejandro Saenz

One-dimensional quantum droplets under a linear gravitational-like trap *(12 pages)* . . . . . 063321
Saurab Das, Jayanta Bera, and Ajay Nath

Saturating interaction in coherently coupled two-component Bose-Einstein condensates *(5 pages)* . . . . . 063322
R. Eid, S. Tiengo, M. Lévy, and T. Bourdel

Quantum backreaction in an analog black hole *(17 pages)* . . . . . 063323
G. Ciliberto, R. Balbinot, A. Fabbri, and N. Pavloff

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Adiabatic cooling of planar motion in a Penning-trap ion crystal to sub-millikelvin temperatures *(11 pages)* . . . . . 063110
Wes Johnson, Bryce Bullock, Athreya Shankar, John Zaris, John J. Bollinger, and Scott E. Parker

Asymmetric dissociation of ammonia molecules in a phase-controlled two-color laser field *(7 pages)* . . . . . 063111
Yupeng Liu, Peipei Ge, Yang Liu, Xueqing Duan, Zichen Li, Weibin Liu, Qinxian Su, Min Li, and Peixiang Lu

Chirped magneto-optical trap of molybdenum *(9 pages)* . . . . . 063112
Sai Naga Manoj Paladugu, Nickolas Pilgram, Stephen Eckel, and Eric Norrgard

Quantitative fine-structure-level study of direct-double-Auger-decay effects on level population evolution in krypton under ultrafast x-ray irradiation *(9 pages)* . . . . . 063113
Jie Yan, Cheng Gao, Yongjun Li, Chongyang Chen, Jiaolong Zeng, and Jianmin Yuan

Nondissociative and dissociative ionization of $CO^+$ in intense ultrashort laser pulses *(12 pages)* . . . . . 063114
B. Gaire, K. J. Betsch, Nora G. Kling, M. Zohrabi, Bethany Jochim, T. Severt, S. Roland, K. D. Carnes, and I. Ben-Itzhak

Coulomb crystallization of highly charged $Ni^{12+}$ ions in a linear Paul trap *(8 pages)* . . . . . 063115
Shao-Long Chen, Zhi-qiang Zhou, Guo-sheng Zhang, Jun Xiao, Yao Huang, Ke-Lin Gao, and Hua Guan

Complete suppression of the nondipole drift effect in high-order harmonic generation *(8 pages)* . . . . . 063116
Hailang Wei, Xiaosong Zhu, Pengfei Lan, and Peixiang Lu

Ultrafast dynamics of $O_2^+$ in the $a\,^4\Pi_u$ and $3\,^2\Pi_u$ states by pump-probe measurements using few-cycle near-infrared laser pulses and high-order harmonics *(10 pages)* . . . . . 063117
Kana Yamada, Toshiaki Ando, Atsushi Iwasaki, and Kaoru Yamanouchi

Laser-induced Coulomb explosion dynamics of $H_2$ molecules in helium nanodroplets *(7 pages)* . . . . . 063118
Zhengjun Ye, Jiaxuan Chen, Ruolin Gong, Menghang Shi, Zhejun Jiang, Chenxu Lu, Yue Hu, Xinglei Long, Wenbin Zhang, and Jian Wu

**Ultracold systems and matter waves**

Observable Efimov resonances in light-light-heavy systems *(10 pages)* . . . . . 063301
Karim I. Elghazawy and Chris H. Greene

Refermionized theory of the edge modes of a fractional quantum Hall cloud *(19 pages)* . . . . . 063302
Alberto Nardin and Iacopo Carusotto

Parametric excitations in a harmonically trapped binary Bose-Einstein condensate *(10 pages)* . . . . . 063303
Meiling Wang, Juan Wang, Yan Li, Franco Dalfovo, and Chunlei Qu

Dynamics of vortices in uniform Bose quantum liquids *(9 pages)* . . . . . 063304
Shiyi Wang, Liang Duan, Liangwei Dong, and Zhan-Ying Yang

Macroscopic self-trapping in the dynamical tunneling of a Bose-Einstein condensate *(16 pages)* . . . . . 063305
Sebastian Wüster, Joy Cree, and Matthew J. Davis

Magneto-optical trap of silver and potassium atoms *(6 pages)* . . . . . 063306
Michael Vayninger, Angela Xiang, Nachiket D. Bhanushali, Xiaoyu Chen, Mohit Verma, Shaozhen Yang, Rohan T. Kapur, David DeMille, and Zoe Z. Yan

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Feshbach resonances in predissociated states of excited ozone *(9 pages)* . . . . . 062820
V. Tyuterev, V. Kokoouline, O. Egorov, S. Vasilchenko, A. Solodov, T. Rigault, D. Mondelain, and A. Campargue

Formation of ultracold $^{39}K$ $^{133}Cs$ Feshbach molecules *(10 pages)* . . . . . 062821
Charly Beulenkamp, Krzysztof P. Zamarski, Robert C. Bird, C. Ruth Le Sueur, Jeremy M. Hutson, Manuele Landini, and Hanns-Christoph Nägerl

Fragmentation of $CO_2^{2+}$ into $C^+ + O^+ + O$ in collisions with 1 MeV/u $C^{4+}$ ions *(9 pages)* . . . . . 062822
Mingliang Duan, Zhencen He, Zhuohang He, Baoren Wei, and Zhimin Hu

Diffraction by circular and triangular apertures as a diagnostic tool of twisted matter waves *(19 pages)* . . . . . 062823
M. Maksimov, N. Borodin, D. Kargina, D. Naumov, and D. Karlovets

**Light-induced processes in atomic-scale systems**

Microscopic analysis of above-threshold ionization driven by squeezed light *(20 pages)* . . . . . 063101
J. Rivera-Dean, P. Stammer, C. Figueira de Morisson Faria, and M. Lewenstein

Impact of electron correlation on photoelectron angular distributions in sequential double photoionization of $Ne^+$ *(11 pages)* . . . . . 063102
Holly Lavery, Andrew C. Brown, and Hugo W. van der Hart

High-fidelity individual addressing of single atoms in quantum registers at three-photon laser excitation of Rydberg states *(10 pages)* . . . . . 063103
N. N. Bezuglov, I. I. Beterov, A. Cinins, K. Miculis, V. M. Entin, P. I. Betleni, G. Suliman, V. V. Gromyko, D. B. Tretyakov, E. A. Yakshina, and I. I. Ryabtsev

Attosecond time delays at Cooper minima in valence-shell photoionization of alkali-metal and alkaline-earth-metal atoms *(11 pages)* . . . . . 063104
Adam J. C. Singor, Dmitry V. Fursa, Igor Bray, and Anatoli S. Kheifets

Influence of electron-wave-packet amplitude and phase modulations on photoelectron angular distributions in strong-field ionization *(9 pages)* . . . . . 063105
Zheming Zhou, Yongkun Chen, Yang Li, Yidian Tian, Peipei Ge, Yueming Zhou, and Peixiang Lu

Magic wavelengths for optical clock transitions in $^{85}Rb$, $^{133}Cs$, and $^{223}Fr$ in visible-near-infrared spectrum *(14 pages)* . . . . . 063106
Jyoti, Mandeep Kaur, Tiantian Shi, and Jingbiao Chen

Long-wavelength reshaping of the high-order harmonic spectrum generated by an intense multicycle near-IR field in gas *(6 pages)* . . . . . 063107
B. V. Rumiantsev, A. V. Pushkin, P. A. Shulyndin, E. A. Migal, and F. V. Potemkin

Splitting of the three-body Förster resonance in Rb Rydberg atoms as a measure of the dipole-dipole interaction strength *(8 pages)* . . . . . 063108
I. I. Ryabtsev, I. N. Ashkarin, I. I. Beterov, D. B. Tretyakov, E. A. Yakshina, V. M. Entin, and P. Cheinet

High-order harmonic generation with orbital angular momentum beams: Beyond-dipole corrections *(10 pages)* . . . . . 063109
Esra Ilke Albar, Valeriia P. Kosheleva, Heiko Appel, Angel Rubio, and Franco P. Bonafé

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Variational studies of the rovibrational spectra of $DT^+$ and $T_2^+$ ions *(6 pages)* . . . . . 062804
D. T. Aznabayev, D. B. Zhomartova, A. K. Bekbaev, and Vladimir I. Korobov

Resonance transitions in electron-impact ionization of $CF_4$ studied by angle-resolved ($e$, $e$ + ion) spectroscopy *(7 pages)* . . . . . 062805
Noboru Watanabe and Masahiko Takahashi

Two-loop electron self-energy in the bound-electron $g$ factor: Diagrams in momentum-coordinate representation *(16 pages)* . . . . . 062806
V. A. Yerokhin, B. Sikora, Z. Harman, and C. H. Keitel

Modulation transfer spectroscopy and isotope shifts of the $^1S_0 \rightarrow {}^3P_1$ transition of ytterbium *(10 pages)* . . . . . 062807
Meng Gu, Konrad Koenigsmann, Jin Yang, and Peter Schauss

Confined variational method applied to low-energy electron-lithium collisions *(5 pages)* . . . . . 062808
Xian-Jun Li, Deng-Xin Zhao, Meng-Shan Wu, Jun Jiang, Zong-Chao Yan, Kalman Varga, and Jun-Yi Zhang

Triplet-state transitions in beryllium: Accurate energies and oscillator strengths *(17 pages)* . . . . . 062809
Saeed Nasiri, Ludwik Adamowicz, and Sergiy Bubin

Calculation of cross sections for electron scattering on $Li_2$ *(17 pages)* . . . . . 062810
Haadi Umer, Liam H. Scarlett, Adam J. C. Singor, Igor Bray, Mark C. Zammit, and Dmitry V. Fursa

QED calculations of intra-$L$-shell doubly excited states in Be-like ions *(13 pages)* . . . . . 062811
A. V. Malyshev, Y. S. Kozhedub, V. M. Shabaev, and I. I. Tupitsyn

Comparative classical and quantal study of the $HeNa^+$ and $HeK^+$ three-body association *(12 pages)* . . . . . 062812
Ricardo Manuel García-Vázquez, Thierry Stoecklin, and Philippe Halvick

Two-loop vacuum polarization in a Coulomb field *(11 pages)* . . . . . 062814
S. A. Volkov, V. A. Yerokhin, Z. Harman, and C. H. Keitel

High-precision EUV spectroscopy of the $2s2p\ ^1P_1$ - $2s^2\ ^1S_0$ transition in Be-like $S^{12+}$ and $Cl^{13+}$: Test of QED effects *(11 pages)* . . . . . 062815
X. P. Zhou, X. Liu, W. Q. Wen, Y. Yuan, H. K. Huang, Z. K. Huang, H. B. Wang, M. Y. Wan, J. Xiao, Y. S. Kozhedub, A. V. Malyshev, V. M. Shabaev, J. G. Li, S. F. Zhang, and X. Ma

Experimental observation of quantum interferences in CO-$H_2$ rotational energy transfer at room temperature *(8 pages)* . . . . . 062816
Hamza Labiad, Alexandre Faure, and Ian R. Sims

Electron-impact fragmentation dynamics of carbonyl sulfide: A combined experimental and theoretical study *(12 pages)* . . . . . 062817
Soumya Ghosh, Narayan Kundu, Aryya Ghosh, and Dhananjay Nandi

Elastic and spin-changing cross sections of spin-polarized atomic tritium *(16 pages)* . . . . . 062818
M. G. Elliott and B. J. P. Jones

*Ab initio* correlated calculations without finite-basis-set error: Numerically precise all-electron random-phase-approximation correlation energies for diatomic molecules *(20 pages)* . . . . . 062819
Hao Peng and Xinguo Ren

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).
The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

PHYSICAL REVIEW A THIRD SERIES, VOLUME 112, NUMBER 6 DECEMBER 2025

Energy-embedded neural solvers for one-dimensional quantum systems *(10 pages)* . . . . . 062611
Yi-Qiang Wu, Xuan Liu, Hanlin Li, and Fuqiang Wang

Time evolution of controlled many-body quantum systems with matrix product operators *(9 pages)* . . . . . 062612
Llorenç Balada Gaggioli and Jakub Mareček

Information reconciliation for phase shift keying discrete modulation continuous-variable quantum key distribution *(8 pages)* . . . . . 062613
Zhenguo Lu, Weilin Liu, Yu Zhang, Zengliang Bai, and Yongmin Li

Single-qudit control in $^{87}$Sr via optical nuclear electric resonance *(9 pages)* . . . . . 062614
Johannes K. Krondorfer, Matthias Diez, and Andreas W. Hauser

Multiple-noise-resilient nonadiabatic geometric quantum control of solid-state spins in diamond *(10 pages)* . . . . . 062615
Si-Qi Chen, Qi-Tao Duan, Chengxian Zhang, and He Lu

High-fidelity quasideterministic entanglement generation using phase-matched spectral islands in a zero-added-loss multiplexing architecture *(17 pages)* . . . . . 062616
Jeffrey H. Shapiro, Clark Embleton, Michael G. Raymer, and Brian J. Smith

Observation of power superbroadening of spectral line profiles on an IBM quantum processor *(8 pages)* . . . . . 062617
Ivo S. Mihov and Nikolay V. Vitanov

Discovering autonomous quantum error correction via deep reinforcement learning *(13 pages)* . . . . . 062618
Yue Yin, Tailong Xiao, Xiaoyang Deng, Ming He, Jianping Fan, and Guihua Zeng

Exact spectral gaps of random one-dimensional quantum circuits *(13 pages)* . . . . . 062619
Andrew E. Deneris, Pablo Bermejo, Paolo Braccia, Lukasz Cincio, and M. Cerezo

Quantum-classical computing for time-dependent ion-atom collision dynamics: Applications to charge-transfer cross-section simulations *(18 pages)* . . . . . 062620
Minchen Qiao and Yu-xi Liu

Rotation errors due to field quantization for simultaneously driven atoms *(9 pages)* . . . . . 062621
Hunter Lindemann, Shanon Vuglar, and Julio Gea-Banacloche

Supersensitive noise sensing based on high-spin systems *(12 pages)* . . . . . 062622
Yangyang Lv, Wen Yang, and Qijun Zhi

## PART B

**Atomic and molecular structure and dynamics; high-precision experiments**

Test of charge-conjugation symmetry via microwave spectroscopy of positronium *(7 pages)* . . . . . 062801
R. J. Daly, K. P. Habdas, D. M. Newson, J. Pérez-Ríos, R. E. Sheldon, and D. B. Cassidy

*Ab initio* multiconfigurational calculations of experimentally significant energy levels and transition rates in Lr I ($Z = 103$) *(8 pages)* . . . . . 062802
Joseph S. Andrews, Andrey I. Bondarev, Per Jönsson, Jon Grumer, Sebastian Raeder, Stephan Fritzsche, and Jacek Bieroń

Extension of the simplified model and its application to mutual neutralization processes in collisions with oxygen cations *(10 pages)* . . . . . 062803
Ya. V. Voronov, S. A. Yakovleva, and A. K. Belyaev

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

PHYSICAL REVIEW A THIRD SERIES, VOLUME 112, NUMBER 6 DECEMBER 2025

Multiplayer conflict avoidance through entangled quantum walks *(20 pages)* . . . . . 062439
Honoka Shiratori, Tomoki Yamagami, Etsuo Segawa, Takatomo Mihana, André Röhm, and Ryoichi Horisaki

Quantifying information loss of quantum channels *(11 pages)* . . . . . 062440
Yuan Li, Shunlong Luo, Yuan Sun, and Shuaijie Wang

Minimal-error quantum state discrimination versus robustness of entanglement: More indistinguishability with less entanglement *(16 pages)* . . . . . 062441
Debarupa Saha, Kornikar Sen, Chirag Srivastava, and Ujjwal Sen

Towards improved quantum machine learning for molecular force fields *(15 pages)* . . . . . 062442
Yannick Couzinié, Shunsuke Daimon, Hirofumi Nishi, Natsuki Ito, Yusuke Harazono, and Yu-ichiro Matsushita

Linking barren plateaus to effective parameters in deep rotation-gate-based parameterized quantum circuits *(20 pages)* . . . . . 062443
Yuhan Yao and Yoshihiko Hasegawa

**Quantum technologies**

Optimal strategies for transient and equilibrium quantum thermometry using Gaussian and non-Gaussian probes *(19 pages)* . . . . . 062601
Asghar Ullah, M. Tahir Naseem, and Özgür E. Müstecaplioğlu

Quantum entanglement in the *C* band coexisting with data transmission in the *L* band *(11 pages)* . . . . . 062602
Yue Luo, Yun-Ru Fan, Kai Guo, Jun-Tao Zhang, Hao Li, Guang-Wei Deng, You Wang, Hai-Zhi Song, Li-Xing You, Guang-Can Guo, and Qiang Zhou

Reinforcement learning for optimal control of spin magnetometers *(9 pages)* . . . . . 062603
Logan W. Cooke and Stefanie Czischek

Reducing depth and measurement weights in Pauli-based computation *(26 pages)* . . . . . 062604
Filipa C. R. Peres and Ernesto F. Galvão

Penalty-free approach to accelerating constrained quantum optimization *(18 pages)* . . . . . 062605
David Bucher, Jonas Stein, Sebastian Feld, and Claudia Linnhoff-Popien

Non-Gaussian dissipative quantum thermometry beyond Gaussian bounds *(8 pages)* . . . . . 062606
Pritam Chattopadhyay

Tunable non-Gaussianity and exact higher-order coherences for quantum advantage *(23 pages)* . . . . . 062607
Arash Azizi

Resource-efficient loss-aware photonic-graph-state preparation using atomic emitters *(22 pages)* . . . . . 062608
Eneet Kaur, Ashlesha Patil, and Saikat Guha

Loss-tolerant parallelized Bell-state generation with a hybrid cat qudit *(17 pages)* . . . . . 062609
Z. M. McIntyre and W. A. Coish

Single-copy-based hyperentanglement purification using high-dimensional positive-operator-valued measures *(10 pages)* . . . . . 062610
Peng Wang, Zi-Hao Wei, Zhe Yang, Chun-Yan Li, Rui-Yang Yuan, and Bao-Cang Ren

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Interpretable representation learning of quantum data enabled by probabilistic variational autoencoders *(15 pages)* . . . . . 062423
Paulin de Schoulepnikoff, Gorka Muñoz-Gil, Hendrik Poulsen Nautrup, and Hans J. Briegel

Quantum separability criteria based on symmetric measurements *(11 pages)* . . . . . 062424
Yu Lu, Wen Zhou, Meng Su, Hong-Xing Wu, Shao-Ming Fei, and Zhi-Xi Wang

Inference of response functions with the help of machine-learning algorithms *(8 pages)* . . . . . 062425
Doga Murat Kurkcuoglu, Gabriel N. Perdue, Alessandro Roggero, and Rajan Gupta

Suboptimality of parity for distilling correlations with nontrivial marginals *(8 pages)* . . . . . 062426
Syed Affan Aslam, Areej Ilyas, and Jibran Rashid

Distribution of nonlocality on quantum random circuits *(19 pages)* . . . . . 062427
Andrés Camilo Granda Arango, Federico Hernán Holik, Roberto Giuntini, Hector Freytes, and Giuseppe Sergioli

Detecting genuine multipartite entanglement using moments of positive maps *(15 pages)* . . . . . 062428
Saheli Mukherjee, Bivas Mallick, Sahil Gopalkrishna Naik, Ananda G. Maity, and A. S. Majumdar

Device-independent verification of controlled quantum controlled-NOT-gate teleportation *(15 pages)* . . . . . 062429
Yi-Ning Li, Neng-Fei Gong, Ru-Qing Zhang, Jing-Wei Wen, and Tie-Jun Wang

Beyond integral-domain stabilizer codes *(7 pages)* . . . . . 062430
Lane G. Gunderman

Adaptive random compiler for Hamiltonian simulation *(12 pages)* . . . . . 062431
Yun-Zhuo Fan, Yu-Xia Wu, and Dan-Bo Zhang

Dynamics of quantum information and entanglement in two qubits coupled to a Bose-Einstein condensate of microwave-shielded polar molecules *(9 pages)* . . . . . 062432
Abdelâali Boudjemâa and Qing-Shou Tan

Qubit-channel metrology with highly noisy initial states and additional undesirable noisy evolution *(16 pages)* . . . 062433
David Collins and Taylor Larrechea

Measurement-device-independent Schmidt number certification of all entangled states *(11 pages)* . . . . . 062434
Saheli Mukherjee, Bivas Mallick, Arun Kumar Das, Amit Kundu, and Pratik Ghosal

Estimation of multivariate traces of states given partial classical information *(14 pages)* . . . . . 062435
Kyrylo Simonov, Rafael Wagner, and Ernesto F. Galvão

Single-site entanglement as a marker for quantum phase transitions at nonzero temperatures *(10 pages)* . . . . . 062436
Willdauany C. de Freitas da Silva, Andressa R. Medeiros-Silva, Rubem Mondaini, Vivian V. França, and Thereza Paiva

Phases of Floquet code under local decoherence *(24 pages)* . . . . . 062437
Yuchen Tang and Yimu Bao

Variational-quantum-eigensolver solution for Lindblad-driven nonequilibrium electron-transport problems *(9 pages)* . . . . . 062438
Yi Liu, Zixuan Hu, Xiao Zheng, and Zhenyu Li

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Sequential sharing of entanglement via probabilistic projective measurements *(14 pages)* . . . . . 062407
Yan-Ling Wang, Shi-Min Ye, Wei Chen, Zhi-Xiang Jin, and Mao-Sheng Li

Weight-based measure of quantum memory as a universal and operational benchmark *(13 pages)* . . . . . 062408
Jinghang Zhang and Yu Luo

Vortex detection from quantum data *(11 pages)* . . . . . 062409
Chelsea A. Williams, Annie E. Paine, Antonio A. Gentile, Daniel Berger, and Oleksandr Kyriienko

Adaptive interpolating quantum transform: A quantum-native framework for efficient transform learning *(7 pages)* . . . . . 062410
Gekko Budiutama, Shunsuke Daimon, Hirofumi Nishi, Ryui Kaneko, Tomi Ohtsuki, and Yu-ichiro Matsushita

Heralded qudit-based high-dimensional entanglement generation for hybrid photon-emitter system by waveguide-mediated scattering *(17 pages)* . . . . . 062411
Fang-Fang Du, Ling-Hui Li, Qiu-Lin Tan, and Zhuo-Ya Bai

Estimation of nonlinear physical quantities by measuring ancillas *(12 pages)* . . . . . 062412
Nhat A. Nghiem and Tzu-Chieh Wei

Logical channels in approximate Gottesman-Kitaev-Preskill error correction *(27 pages)* . . . . . 062413
Mahnaz Jafarzadeh, Jonathan Conrad, Rafael N. Alexander, and Ben Q. Baragiola

Synthesis of single-qutrit circuits from Clifford+$R$ gates *(13 pages)* . . . . . 062414
Erik J. Gustafson, Henry Lamm, Diyi Liu, Edison M. Murairi, and Shuchen Zhu

Resource theory of nonrevivals with applications to quantum many-body scars *(8 pages)* . . . . . 062415
Roy J. Garcia, Kaifeng Bu, Liyuan Chen, and Anton M. Graf

Quantum optimization on Rydberg-atom arrays with arbitrary connectivity: Gadget limitations and a heuristic approach *(10 pages)* . . . . . 062416
Pierre Cazals, Amalia Sorondo, Victor Onofre, Constantin Dalyac, Wesley Coelho, and Vittorio Vitale

Sachdev-Ye-Kitaev-model–based $\beta$-regime-dependent two-qubit dynamical wormhole-inspired teleportation protocol simulation *(15 pages)* . . . . . 062417
Sudhanva Joshi and Sunil Kumar Mishra

Family of two-parameter multipartite entanglement measures *(15 pages)* . . . . . 062418
Yu Luo, Zhihua Guo, Fanxu Meng, and Chen-Ming Bai

Effect of multiqubit correlated noise on surface-code thresholds *(7 pages)* . . . . . 062419
SiYing Wang, Yue Yan, ZhiXin Xia, and Xiang-Bin Wang

Two variations of quantum phase estimation for reducing circuit error rates: Application to the Harrow-Hassidim-Lloyd algorithm *(18 pages)* . . . . . 062420
Yonghae Lee, Minjin Choi, Youngho Min, Eunok Bae, and Sunghyun Bae

Investigating pure state uniqueness in tomography via optimization *(20 pages)* . . . . . 062421
Jiahui Wu, Zheng An, Chao Zhang, Xuanran Zhu, Shilin Huang, and Bei Zeng

Dynamical properties and applications of discrete time nonunitary quantum walks *(25 pages)* . . . . . 062422
Lihao Xu, Meng Li, and Xiaoming Sun

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).
The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Nonresonant quantum dynamics of a relativistic electron in counterpropagating laser beams *(13 pages)* . . . . . 062224
E. Raicher and Q. Z. Lv

Direct measurement of the quantum geometric tensor in pseudo-Hermitian systems *(12 pages)* . . . . . 062225
Ze-Hao Huang, Hai-Tao Ding, and Li-Jun Lang

Separation of relaxation timescales via strong system-bath coupling: Dissipative three-level system as a case study *(16 pages)* . . . . . 062226
Brett Min, Matthew Gerry, and Dvira Segal

Information thermodynamics of non-Hermitian quantum systems *(11 pages)* . . . . . 062227
Kui Cao, Qian Du, and Su-Peng Kou

Comparing quantum incompatibility of device sets from an operational perspective *(14 pages)* . . . . . 062228
Kensei Torii, Ryo Takakura, and Ryotaro Imamura

Nonequilibrium quantum thermometry with noncommutative system-bath couplings *(8 pages)* . . . . . 062229
Youssef Aiache, Abderrahim El Allati, İlkay Demir, and Khadija El Anouz

Verification of contextuality by noncontextual experiments *(15 pages)* . . . . . 062230
Jonathan J. Thio, Wilfred Salmon, Crispin H. W. Barnes, Stephan De Bièvre, and David R. M. Arvidsson-Shukur

Geometric control of Bell correlations in path-entangled systems *(6 pages)* . . . . . 062231
H. O. Cildiroglu

Superactivation of Bell nonlocality in pure anyonic states *(15 pages)* . . . . . 062232
Cheng-Qian Xu, Wenhao Ye, and Li You

Distance-based measures and epsilon measures for measurement-based quantum resources *(16 pages)* . . . . . 062233
Arindam Mitra, Sumit Mukherjee, and Changhyoup Lee

Geometric phase in dissipative quantum batteries *(11 pages)* . . . . . 062234
Camila Cristiano, Ludmila Viotti, and Paula I. Villar

**Quantum information science**

Multiparameter quantum metrology at Heisenberg scaling for an arbitrary two-channel linear interferometer with squeezed light *(10 pages)* . . . . . 062401
Atmadev Rai, Danilo Triggiani, Paolo Facchi, and Vincenzo Tamma

Quantum-enhanced distributed sensing using nonlinear optical networks *(13 pages)* . . . . . 062403
Zhongjian Zhang, Ben Wang, Kaimin Zheng, and Lijian Zhang

Algorithm for multireference unitary coupled-cluster quantum computations of molecule systems *(6 pages)* . . . . . 062404
Di Wu, C. L. Bai, H. Sagawa, and H. Q. Zhang

Bending hyperplanes: Nonlinear entanglement witnesses via envelopes of linear witnesses *(11 pages)* . . . . . 062405
AmirHossein Tangestaninejad and Vahid Karimipour

Dynamic circuit for the honeycomb Floquet code *(7 pages)* . . . . . 062406
Jahan Claes

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

**PHYSICAL REVIEW A** **THIRD SERIES, VOLUME 112, NUMBER 6** **DECEMBER 2025**

Wigner entropy conjecture and the interference formula in quantum phase space *(12 pages)* . . . . . 062207
Zacharie Van Herstraeten and Nicolas J. Cerf

Necessary and sufficient condition for the quantum realizability of correlations for arbitrary normalized observables in the Clauser-Horne-Shimony-Holt setup *(23 pages)* . . . . . 062208
Ryosuke Nogami and Jaeha Lee

Exact quantum speed limits *(9 pages)* . . . . . 062209
Arun K. Pati, Brij Mohan, Sahil, and Samuel L. Braunstein

Interference in phase space and phase-only reconstruction *(14 pages)* . . . . . 062210
André Knoll, Leon Cohen, and Wolfgang P. Schleich

Quantum interferometry in external gravitational fields *(20 pages)* . . . . . 062211
Thomas B. Mieling, Thomas Morling, Christopher Hilweg, and Philip Walther

Jaynes-Cummings model as an autonomous Maxwell demon *(16 pages)* . . . . . 062212
Yashovardhan Jha, Dragi Karevski, and Cyril Elouard

Dependence of the recoherence times and recoherence increments on the state of phonon bath in a single-qubit dephasing model *(11 pages)* . . . . . 062213
V. V. Ignatyuk and Ch. Samorodov

Non-Markovian quantum jump method for driven-dissipative two-level systems *(12 pages)* . . . . . 062214
Huanyuan Zhang and Jiasen Jin

Mutually equibiased bases *(13 pages)* . . . . . 062215
Seyed Javad Akhtarshenas, Saman Karimi, and Mahdi Salehi

Semi-device-independent self-testing of unitary operations *(6 pages)* . . . . . 062216
Rajdeep Paul, Prabuddha Roy, and A. K. Pan

Absorbing detectors versus scattering theory *(11 pages)* . . . . . 062217
Will Cavendish and Siddhant Das

Quantum correction to the Langevin cross section in resonant-exchange processes *(20 pages)* . . . . . 062218
I. Simbotin and R. Côté

Topology of the Aharonov-Bohm effect in different reference frames *(7 pages)* . . . . . 062219
Hiram S. M. Rodrigues, Katson W. O. Arévola, and Pablo L. Saldanha

Translating Bell nonlocality to prepare-and-measure scenarios under dimensional constraints *(19 pages)* . . . . . 062220
Matilde Baroni, Eleni Diamanti, Damian Markham, and Ivan Šupić

Multipartite entanglement in a non-Hermitian quadruple-well potential with synthetic gauge fields *(15 pages)* . . . . 062221
Yan-Qiong Ma, Ke-Wen Xiao, Cheng-Jie Wang, and Wen-Yuan Wang

Interferometric and bipartite out-of-time-ordered correlators for non-Markovian open quantum spin chains and the Lipkin-Meshkov-Glick model *(10 pages)* . . . . . 062222
Baibhab Bose, Devvrat Tiwari, and Subhashish Banerjee

Neural network approach to Dirac quantum field theory *(15 pages)* . . . . . 062223
M. Jiang, B. P. Czajka, E. B. James, A. J. Hardaway, C. D. Achammer, Q. Su, and R. Grobe

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

PHYSICAL REVIEW A THIRD SERIES, VOLUME 112, NUMBER 6 DECEMBER 2025

**Ultracold systems and matter waves**

Probing the spatial distribution of *k*-vectors *in situ* with Bose-Einstein condensates *(5 pages)* . . . . . L061301
Samuel Gaudout, Rayan Si-Ahmed, Clément Debavelaere, Menno Door, Pierre Cladé, and Saïda Guellati-Khelifa

Gravitational sensing in the frequency domain using an echo atom interferometer *(7 pages)* . . . . . L061302
Gehrig Carlse, Jaskaran Randhawa, Alex Pouliot, Eduardo Ramos, Thomas Vacheresse, and A. Kumarakrishnan

Interaction-induced chiral-transport inversion *(7 pages)* . . . . . L061303
Li Pan, Qian Liang, Chang-An Yang, Yu Huang, Pengjie Liu, Fanying Xi, Wei Yi, Xiaofan Zhou, and Jian-Song Pan

Fast and direct preparation of a genuine lattice Bose-Einstein condensate via the quantum Mpemba effect *(6 pages)* . . . . . L061304
Philipp Westhoff, Sebastian Paeckel, and Mattia Moroder

Geometric filtering effect in expanding Bose-Einstein condensate shells *(6 pages)* . . . . . L061305
A. Tononi, M. Lewenstein, and L. Santos

**Photonics, nonlinear optics, and optomechanics**

Pulse-stacking technique for nonlinear Compton scattering: Compensation of nonlinear broadening and generation of multicolor gamma sources *(5 pages)* . . . . . L061501
Antonina Timoshenko, Maxim Malakhov, Alexander Fedotov, and Sergey Rykovanov

**Quantum optics**

Light statistics from large ensembles of independent two-level emitters: Classical and nonclassical effects *(7 pages)* . . . . . L061701
M. Bojer, A. Cidrim, P. P. Abrantes, R. Bachelard, and J. von Zanthier

## ARTICLES

**Fundamental concepts**

Continuous crossover from quantum-limit-bounded evolution to exponential delay *(14 pages)* . . . . . 062201
A. M. Zheltikov

Superluminal signaling witness for quantum state reduction *(8 pages)* . . . . . 062202
Aritro Mukherjee, Lisa Lenstra, Lotte Mertens, and Jasper van Wezel

Bulk-boundary correspondence and infernal points in the non-Hermitian trimer Su-Schrieffer-Heeger model *(8 pages)* . . . . . 062204
K. J. Tang, H. T. Cui, and H. F. Mu

Maximal coin-position entanglement and non-Hermitian skin effect in discrete-time quantum walks *(14 pages)* . . . . . 062205
Ding Cheng, Yi Li, Hao Zhao, Haijun Kang, Cui Kong, Jiguo Wang, Feng Mei, Chuanjia Shan, and Jibing Liu

Reducing circuit depth in Lindblad simulations via step-size extrapolation *(19 pages)* . . . . . 062206
Pegah Mohammadipour and Xiantao Li

*(Continued)*

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).

# PHYSICAL REVIEW A™

**For editorial and subscription correspondence, please see inside front cover**
**(ISSN: 2469-9926)**

**PERIODICALS**
**Postmaster send address changes to:**

**APS Subscription Services**
**P.O. Box 41**
**Annapolis Junction, MD 20701**

**THIRD SERIES, VOLUME 112, NUMBER 6**
**PARTS A AND B**

*CONTENTS*

**DECEMBER 2025**

***The Table of Contents is a total listing of Parts A and B.***
***Part A consists of pages L060201–062622, and Part B pages 062801–069901(E).***

## PART A

## LETTERS

**Fundamental concepts**

Hamiltonian with energy levels corresponding to Riemann zeros *(5 pages)* . . . . . L060201
Xingpao Suo

**Quantum information science**

Beating the optimal verification of entangled states via collective strategies *(7 pages)* . . . . . L060401
Ye-Chao Liu and Jiangwei Shang

**Quantum technologies**

Metrology of open quantum systems from emitted radiation *(7 pages)* . . . . . L060601
Siddhant Midha and Sarang Gopalakrishnan

**Light-induced processes in atomic-scale systems**

Optical transitions near the elusive $5s$-$4f$ level crossing in highly charged osmium with sensitivity to physics beyond the standard model *(7 pages)* . . . . . L061101
Nils-Holger Rehbehn, Lakshmi Priya Kozhiparambil Sajith, Michael K. Rosner, Charles Cheung, Sergey G. Porsev, Marianna S. Safronova, Steven Worm, Dmitry Budker, Thomas Pfeifer, José R. Crespo López-Urrutia, and Hendrik Bekker

Interplay between the electric-dipole and nondipole-induced forward-backward asymmetries in the inner-shell photoionization of chiral molecules *(6 pages)* . . . . . L061102
Nikolay M. Novikovskiy, Dmitrii V. Rezvan, Laura Sommerlad, Arno Ehresmann, Till Jahnke, Reinhard Dörner, Markus S. Schöffler, and Philipp V. Demekhin

All-optical field-free molecular orientation with higher order parameters *(6 pages)* . . . . . L061103
Shinichirou Minemoto, Naoki Hara, Md. Maruf Hossain, and Hirofumi Sakai

Parallels between chaotic scattering and heating in cold ion-atom collisions *(5 pages)* . . . . . L061104
Saajid Chowdhury and Jesus Perez-Rios

*(Continued)*

2469-9926(202512)112:6:B;1-S

This paper was highlighted in the APS publication *Physics* (physics.aps.org).

The editors and referees of PRA find these papers to be of particular interest, importance, or clarity. Please see our Announcement Phys. Rev. A 88, 020001 (2013).