

ISSN: 0256-307X

中国物理快报

Chinese Physics Letters

Volume 27 Number 5 May 2010

A Series Journal of the Chinese Physical Society
Distributed by IOP Publishing

Online: <http://www.iop.org/journals/cpl>
<http://cpl.iphy.ac.cn>

CHINESE PHYSICAL SOCIETY

JUST FOR AUTHORS
— CHINESE PHYSICS LETTERS

Chip-Based Square Wave Dynamic Micro Atom Trap *

DAN Lin(但林)^{1,2,4}, YAN Hui(颜辉)^{1,2,3}, WANG Jin(王谨)^{1,2**}, ZHAN Ming-Sheng(詹明生)^{1,2}¹State Key Laboratory of Magnetic and Atomic and Molecular Physics, and Wuhan National Laboratory for Optoelectronics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan 430071²Center for Cold Atom Physics, Chinese Academy of Sciences, Wuhan 430071³Laboratory of Quantum Information Technology, ICMP and SPTE, South China Normal University, Guangzhou 510006⁴Graduate School of Chinese Academy of Sciences, Beijing 100049

(Received 19 August 2009)

We propose a scheme for a chip-based dynamic micro atom trap where the trap potentials are created by square wave radiation and an inhomogeneous static magnetic field. The parameters of this kind of trap array can be modulated dynamically. Both one-dimensional (1-D) and two-dimensional (2-D) trap array potentials for ⁶Li atoms are discussed. The 1-D trap is combined by a square wave radiation (6 kHz) and a gradient magnetic field (300 G/cm), the array constant of 1-D trap is 0.85 μm. Since the trap array does not require any laser field, it can be easily integrated on a chip and it is useful in applications of scalable quantum information processing.

PACS: 32.80.Pj, 03.75.Lm, 03.75.Dg, 42.50.Gy

DOI: 10.1088/0256-307X/27/5/053201

Recently, the research of the atom chip has attracted much attention.^[1,2] Similar to dc and rf radiation, it can be applied to chip wires to form atom traps.^[3–5] In order to control the atoms more flexibly, researchers have adopted rf mixing^[6–8] and rf combs^[9] in atom traps. Chip-based neutral atom traps are suitable for quantum information processing (QIP).^[10–13] However, it is difficult to realize analog frequency mixing and frequency combs. Since the control of the square wave is more versatile than that of sine wave, the digital signal is more suitable for chip-based rf atom traps.^[14] In this Letter, we propose a dynamic micro trap scheme. A square wave radiation and an inhomogeneous static magnetic field are used to generate dynamic micro trap, and the trap is very easy to integrate with other systems. The trap array generated by the square wave and magnetic field can be modulated dynamically. It is different from the ordinary static magnetic trap array. The feature of the one-dimensional trap array is mainly studied, and the scheme of the two-dimensional trap array is briefly discussed.

The analog rf signals cannot be directly generated by a digital signal generator without a digital-to-analog converter (DAC). A sine signal provides only single frequency, and frequency comb or multi-frequency are usually generated by analog frequency mixing. In contrast, square wave can be considered as a mixture of a serial of multi-frequency sine waves and described as^[14]

$$B(t) = B_0 \left[\sin(\omega t) + \frac{1}{3} \sin(3\omega t) + \dots + \frac{1}{n} \sin(n\omega t) + \dots \right], \quad n = 1, 3, 5, \dots, \quad (1)$$

where $\omega = 2\pi/T$, and T is the period of the square wave, $\pi B_0/4$ is its amplitude. According to Eq. (1), the combined field of a square wave and others is equal to multi-frequency sine wave fields, that is, a square wave could be considered as a series of analog rf signals.

In a homogeneous static magnetic field, if we apply a square wave field with the frequency being nearly resonant with the Zeeman sublevel transition of atom, then the far higher-order detuned frequencies of square wave can be treated as small perturbations. This square wave is similar to monochromatic analog frequency radiation and can be used to build micro rf traps.^[14]

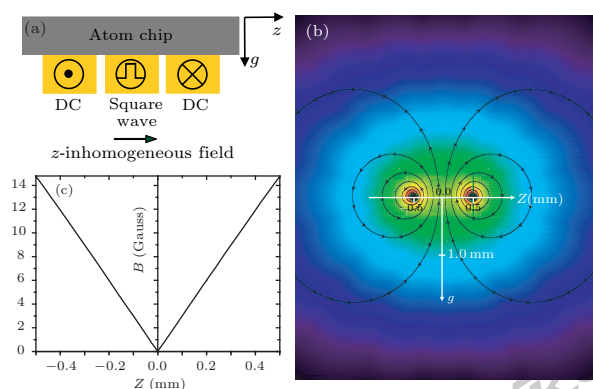


Fig. 1. (a) Setup of square wave on an atom chip, which is perpendicular to the gravity field. (b) The flux density of the inhomogeneous static magnetic field. (c) Intensity distribution of the inhomogeneous magnetic field.

If the external bias magnetic field is inhomogeneous, the trap will be more complex and more in-

*Supported by the National Basic Research Program of China under Grant Nos 2005CB724505/1 and 2006CB921203, the National Natural Science Foundation of China under Grant No 10774160, and Wuhan National Laboratory for Optoelectronics under Grant No P080001.

**To whom correspondence should be addressed. Email: wangjin@wipm.ac.cn

© 2010 Chinese Physical Society and IOP Publishing Ltd

teresting. A simple setup for the usage of a square wave on an atom chip is shown in Fig. 1(a). The two contra-propagated dc currents can be used to form a linear magnetic field between the two side wires; the square wave will propagate via the central wire. The space of two side wires is 1.0 mm; two dc currents are set to be 37.5 mA. Thus an atom trap can be formed near the chip surface. At a height of 1.0 mm from the atom chip, the orientation of inhomogeneous magnetic field is along the z axis and parallel to the surface of atom chip; the intensity of magnetic field B is exactly proportional to the distance $|z|$ (as shown in Figs. 1(b) and 1(c)), the gradient of the linear field is approximately 300 G/cm.

In inhomogeneous static magnetic field, different subsets of square wave will resonate with the Zeeman sublevels of neutral atoms at proper positions. For example, if we assume a one-dimensional (1-D) linear static magnetic field in the z direction, as shown in Fig. 1, and $B(z) = bz$, where b is the gradient, then all the components could be resonant with certain energy states at some positions. In Fig. 2, the frequency of the square wave is supposed to be $f = 6$ kHz, and $b = 300$ G/cm, according to $z = \hbar\omega_n/b\mu_B g_F \Delta m_F$, where $\Delta m_F = 1$, $g_F = -2/3$ in the case of ${}^6\text{Li}$, then frequency components $\omega = 2\pi \times 6$ kHz, $3\omega = 2\pi \times 18$ kHz, and $5\omega = 2\pi \times 30$ kHz will resonate with Zeeman sublevels at positions $z = \pm 0.215 \mu\text{m}$, $\pm 0.644 \mu\text{m}$, and $\pm 1.07 \mu\text{m}$, respectively.

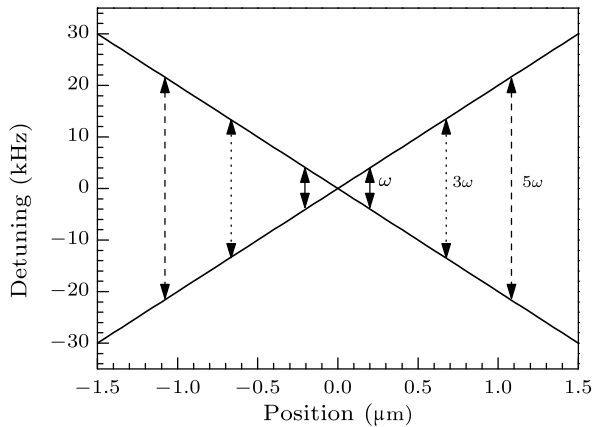


Fig. 2. Square wave resonate with ${}^6\text{Li}$ atom levels in 1-D linear magnetic field, $B(z) = bz$, $b = 300$ G/cm. The frequency of the square wave is 6 kHz.

When an analog rf field (ω) interacts with a two-sublevel (m_F, m'_F) atom system (${}^6\text{Li}$), the coupling strength between $|F, m_F\rangle$ and $|F, m'_F\rangle$ is^[15]

$$\mu = \frac{1}{4} g_F \mu_B (\mathbf{B}_{\text{rf}} \times \hat{e}_z) \sqrt{F(F+1) - m_F m'_F}, \quad (2)$$

where g_F is the g factor, and \hat{e}_z is the direction of the 1-D linear static magnetic field ($B(z)$). As discussed in Ref. [14], the eigenvalues of this coupling system

read

$$E_{\pm}(z) = \pm \frac{1}{2} \sqrt{[\mu_B g_F B(z) - \hbar\omega]^2 + \hbar^2 \Omega_R^2}, \quad (3)$$

where Ω_R is the Rabi frequency,^[16] $\Omega_R = \mu/\hbar$.

The case of a square wave field is different from that of an analog rf field. For the frequency components, when Rabi frequency ($\Omega_R < \omega$) is sufficiently low and frequency separation (2ω) is large enough, the coupling positions can be separated as shown in Fig. 3. In a special range, only one nearly resonant component should be considered, while others can be considered as the dynamic Stark shift.^[17] For example, from 0 to $0.5 \mu\text{m}$, the resonant frequency is ω as shown in Fig. 3, the adiabatic potential is determined by ω , and other frequency components ($3\omega, 5\omega, 7\omega, \dots$) only cause dynamic Stark shifts.

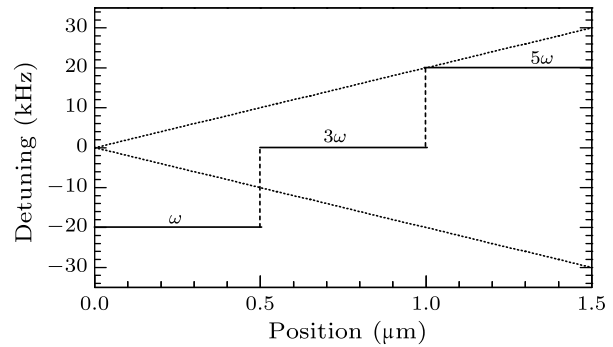


Fig. 3. Separation of the coupling frequency in space. The dotted lines represent the Zeeman sublevels in a 1-D linear magnetic field, $B(z) = bz$, $b = 300$ G/cm; the solid lines define the local coupling frequency.

According to Eq. (3), we could determine the dynamic Stark shift by

$$\Delta = \frac{\hbar^2 \Omega_R^2}{4[\mu_B g_F B(z) - \hbar\omega]}.$$

Considering the square wave field, a series of non-resonant frequencies components contribute to the dynamic Stark shift, which should be modified as

$$\Delta_n = \sum_{j \neq n} \frac{\hbar^2 \Omega_R^2}{4[\mu_B g_F B(z) - \hbar\omega_j]}.$$

The consequent Hamiltonian is

$$H(z) = \begin{pmatrix} \frac{\mu_B g_F B(z)}{2} - \frac{\hbar\omega}{2} - \Delta_n & \frac{\hbar\Omega_R}{2} \\ \frac{\hbar\Omega_R}{2} & \mathcal{H}_{22} \end{pmatrix}, \quad (4)$$

$$\mathcal{H}_{22} = -\frac{\mu_B g_F B(z)}{2} + \frac{\hbar\omega}{2} + \Delta_n$$

and the eigenvalues read

$$E_{\pm}(z) = \pm \frac{1}{2} \sqrt{[\mu_B g_F B(z) - \hbar\omega + 2\Delta_n]^2 + \hbar^2 \Omega_R^2}. \quad (5)$$

The near resonant frequencies are strongly coupled with the sublevels at certain positions and the far detuning components also weakly affect the potential energies. According to the Landau-Zener effect,^[18] the atoms are transferred from initial state to another adiabatically. The corresponding adiabatic potentials are described as^[7,9]

$$V_{ad,\pm}(z) = (-1)^{n(z)} \left[E_{\pm}(z) \mp \frac{\hbar\omega_{n(z)}}{2} \right] \mp \sum_{k=1}^{n(z)-1} (-1)^k \hbar\omega_k, \quad (6)$$

where $n = 1, 2, 3, \dots$, $\omega_1 = \omega$, $\omega_2 = 3\omega$, $\omega_3 = 5\omega, \dots$. As shown in Fig. 4, a periodic potential which is similar to the potential of a standing wave can be realized. This potential is a 1-D trap array, and cold atoms can be trapped at the potential minima. The array constant which is defined as the distance between two adjacent potential minima is

$$d = 2\hbar\Delta\omega/(\mu_B g_F b), \quad (7)$$

where $\Delta\omega$ is the frequency difference between two adjacent components. The potential depth is $\hbar\omega - \hbar\Omega_R$, for $b = 300 \text{ G/cm}$, $\Delta\omega = 12 \text{ kHz}$, the array constant is $0.85 \mu\text{m}$. According to Eq. (7), the array constant can be adjusted either by altering the frequency difference or by changing the bias magnetic field gradient. As shown in Fig. 5, the array constant is proportional to the frequency difference and inversely proportional to the gradient of bias magnetic field.

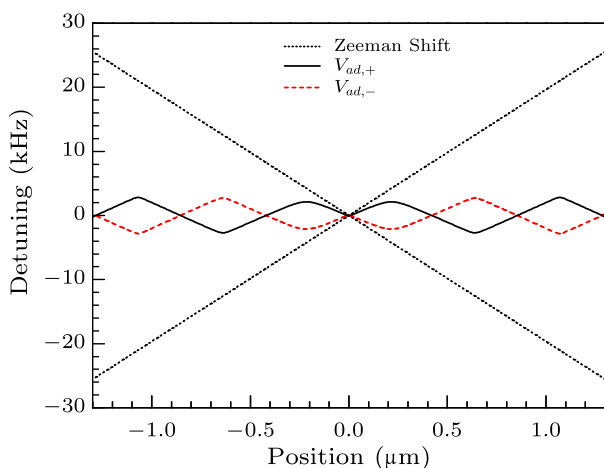


Fig. 4. Periodic adiabatic potential of a square wave in 1-D linear magnetic field. The Rabi frequency Ω_R is set to 1 kHz, b is 300 G/cm, and the array constant is $0.85 \mu\text{m}$.

In contrast to optical trap arrays, this hybrid trap array does not require any laser field, and there is no spontaneous emission involved in the trapping process. Compared with static magnetic array, this trap array can be dynamically tuned. Since this trap array is generated by coupling a square wave field with a static inhomogeneous magnetic field, it can be easily integrated on an atom chip. This kind of dynamic

array can be used for atom optics and atom lithography, it is also a potential candidate for realization of a scalable QIP.^[10–13,19–22] The 1-D trap array can also be used as grating for matter waves and can be modulated dynamically.

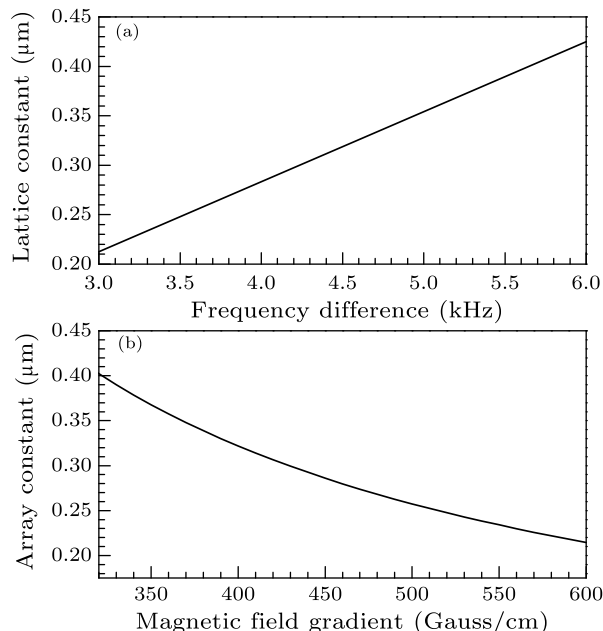


Fig. 5. Dependence of array constant on frequency difference (a) and on the gradient of bias magnetic field (b).

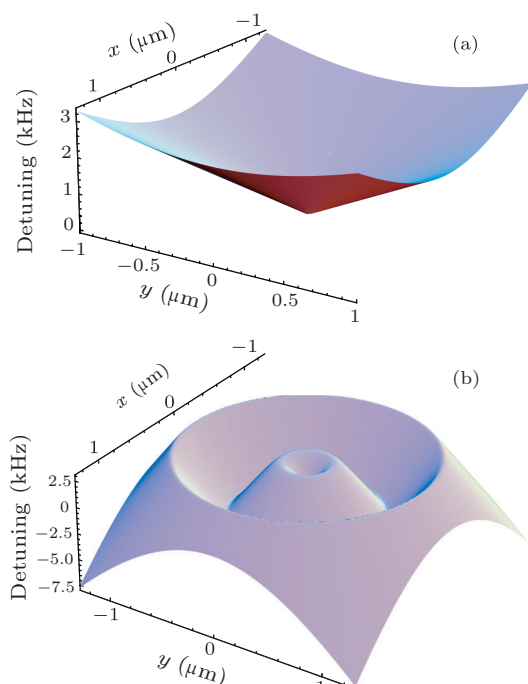


Fig. 6. (a) Two-dimensional magnetic field with gradient $b_r = 300 \text{ G/cm}$. (b) Two-dimensional ring trap potential array for ${}^6\text{Li}$ atoms.

The 1-D trap array can be easily extended to 2-D by perpendicularly applying a homogeneous magnetic field to the atom chip. The 2-D magnetic trap array is defined by a cylindrical field $B(r) =$

$b_{rr}(r = \sqrt{x^2 + y^2})$, where forms the guide potential for weak-field seeking atoms.^[23] The configuration of the 2-D magnetic field and a 2-D hybrid trap array (ring trap potential) are shown in Figs. 6(a) and 6(b). The distance between two adjacent ring potentials is also determined by Eq. (7) and the potential depth is $\hbar\omega - \hbar\Omega_R$. If we ignore the far detuning sine wave components, we can change the number of the ring traps by selecting position of the 2-D magnetic field. This novel ring traps can be applied in atom interferometers.^[24,25]

The above analysis is based on a simple two-level ^6Li atom system, it is also suitable for multi-sublevel systems, such as Rb and Cs.^[7,9,26–28]

In conclusion, we have demonstrated a scheme for a chip-based dynamic micro atom trap, which is combined by a square wave and a static inhomogeneous magnetic field. We calculate the 1-D and 2-D periodic trap arrays for ^6Li atoms. The trap array constant can be modulated dynamically. The 1-D periodic trap array has important applications in dynamic atom gratings, atomic optics and implementing QIP; the 2-D periodic trap array can be used in atom interferometers.

References

- [1] Fortagh J and Zimmermann C 2007 *Rev. Mod. Phys.* **79** 235
- [2] Folman R, Kruger P, Schmiedmayer J, Denschlag J and Henkel C 2002 *Adv. At. Mol. Opt. Phys.* **48** 263
- [3] Schumm T, Hofferberth S, Andersson L M, Wildermuth S, Groth S, Bar-Joseph I, Schmiedmayer J and Kruger P 2005 *Nature Phys.* **1** 57
- [4] Jo G B, Shin Y, Will S, Pasquini T A, Saba M, Ketterle W, Pritchard D E, Vengalattore M and Prentiss M 2007 *Phys. Rev. Lett.* **98** 0300407
- [5] Hofferberth S, Lesanovsky I, Fischer B, Verdu J and Schmiedmayer J 2006 *Nature Phys.* **2** 710
- [6] Lesanovsky I and von Klitzing W 2007 *Phys. Rev. Lett.* **99** 083001
- [7] Lesanovsky I, Schumm T, Hofferberth S, Andersson L M, Kruger P and Schmiedmayer J 2006 *Phys. Rev. A* **73** 033619
- [8] Trebbia J B, Alzar C L G, Cornelussen R, Westbrook C I and Bouchoule I 2007 *Phys. Rev. Lett.* **98** 263201
- [9] Courteille P W, Deh B, Fortagh J, Gunther A, Kraft S, Marzok C, Slama S and Zimmermann C 2006 *J. Phys. B: At. Mol. Opt. Phys.* **39** 1055
- [10] Cirone M A, Negretti A, Calarco T, Kruger P and Schmiedmayer J 2005 *Eur. Phys. J. D* **35** 165
- [11] Treutlein P, Hansch T W, Reichel J, Negretti A, Cirone M A and Calarco T 2006 *Phys. Rev. A* **74** 022312
- [12] Charron E, Cirone M A, Negretti A, Schmiedmayer J and Calarco T 2006 *Phys. Rev. A* **74** 012308
- [13] Yan H, Yang G Q, Shi T, Wang J and Zhan M S 2008 *Phys. Rev. A* **78** 034304
- [14] Shi T, Yan H, Yang G Q, Wang J and Zhan M S 2009 *Acta Phys. Sin.* **58** 1586 (in Chinese)
- [15] Ketterle W and VanDruten N J 1996 *Adv. At. Mol. Opt. Phys.* **37** 181
- [16] Yang X H, Zhang J, Zhang H F and Yan X N 2009 *Chin. Phys. Lett.* **26** 073202
- [17] Zhou X J, Chen X Z, Chen J B, Wang Y Q and Li J M 2009 *Chin. Phys. Lett.* **26** 090601
- [18] Rubbmark J R, Kash M M, Littman M G and Kleppner D 1981 *Phys. Rev. A* **23** 3107
- [19] Gunther A, Kraft S, Zimmermann C and Fortagh J 2007 *Phys. Rev. Lett.* **98** 140403
- [20] Andersson E, Calarco T, Folman R, Andersson M, Hessmo B and Schmiedmayer J 2002 *Phys. Rev. Lett.* **88** 100401
- [21] Timp G, Behringer R E, Tennant D M, Cunningham J E, Prentiss M and Berggren K K 1992 *Phys. Rev. Lett.* **69** 1636
- [22] McClelland J J, Scholten R E, Palm E C and Celotta R J 1993 *Science* **262** 877
- [23] Yan H, Yang G Q, Shi T, Wang J and Zhan M S 2010 *Chin. Phys. B* **19** 023204
- [24] Crookston M B, Baker P M and Robinson M P 2005 *J. Phys. B: At. Mol. Opt. Phys.* **38** 3289
- [25] Fernholz T, Gerritsma R, Kruger P and Spreuw R J C 2007 *Phys. Rev. A* **75** 063406
- [26] Zhang H C, Zhang P F, Xu X P, Han J R and Wang Y Z 2005 *Chin. Phys. Lett.* **22** 83
- [27] Spreuw R J C, Gerz C, Goldner L S, Phillips W D, Rolston S L, Westbrook C I, Reynolds M W and Silvera I F 1994 *Phys. Rev. Lett.* **72** 3162
- [28] Desruelle B, Boyer V, Bouyer P, Birkl G, Lecrivain M, Alves F, Westbrook C I and Aspect A 1998 *Eur. Phys. J. D* **1** 255

Chinese Physics Letters

Volume 27

Number 5

2010

GENERAL

- 050201 **The Multi-Function Jaulent–Miodek Equation Hierarchy with Self-Consistent Sources**
YU Fa-Jun
- 050301 **A New Kind of Integration Transformation in Phase Space Related to Two Mutually Conjugate Entangled-State Representations and Its Uses in Weyl Ordering of Operators**
LV Cui-Hong, FAN Hong-Yi
- 050302 **Evolution of Number State to Density Operator of Binomial Distribution in the Amplitude Dissipative Channel**
FAN Hong-Yi, REN Gang
- 050303 **Evolutionarily Stable Strategies in Quantum Hawk–Dove Game**
Ahmad Nawaz, A. H. Toor
- 050304 **Fidelity Susceptibility in the SU(2) and SU(1,1) Algebraic Structure Models**
ZHANG Hong-Biao, TIAN Li-Jun
- 050305 **Squeezing-Displacement Dynamics for One-Dimensional Potential Well with Two Mobile Walls where Wavefunctions Vanish**
FAN Hong-Yi, CHEN Jun-Hua, WANG Tong-Tong
- 050306 **A New Quantum Secure Direct Communication Scheme with Authentication**
LIU Dan, PEI Chang-Xing, QUAN Dong-Xiao, ZHAO Nan
- 050401 **Mechanical and Thermal Properties of the AH of FRW Universe**
WEI Yi-Huan
- 050501 **Chaotic Dynamics of a Josephson Junction with Nonlinear Damping**
LI Fei, PAN Chang-Ning, ZHANG Dong-Xia, TANG Li-Qiang
- 050502 **Adaptive Function Projective Synchronization of Discrete Chaotic Systems with Unknown Parameters**
WU Zhao-Yan, FU Xin-Chu
- 050503 **Cluster Consensus of Nonlinearly Coupled Multi-Agent Systems in Directed Graphs**
LU Xiao-Qing, Francis Austin, CHEN Shi-Hua
- 050601 **Determination of Mean Thickness of an Oxide Layer on a Silicon Sphere by Spectroscopic Ellipsometry**
ZHANG Ji-Tao, LI Yan, LUO Zhi-Yong, WU Xue-Jian
- 050701 **Preparation and Humidity Sensing Properties of KCl/MCM-41 Composite**
LIU Li, KOU Li-Ying, ZHONG Zhi-Cheng, WANG Lian-Yuan, LIU Li-Fang, LI Wei

THE PHYSICS OF ELEMENTARY PARTICLES AND FIELDS

- 051101 **Prospects on Determining Electric Dipole Moments of Σ and Ξ Hyperons at BESIII**
ZHANG Feng, GAO Yuan-Ning, HUO Lei
- 051301 **B_s Semileptonic Decays to D_s and D_s^* in Bethe–Salpeter Method**
ZHANG Jin-Mei, WANG Guo-Li

NUCLEAR PHYSICS

- 052101 **Neutron Spectroscopic Factors of ${}^7\text{Li}$ and Astrophysical ${}^6\text{Li}(n,\gamma){}^7\text{Li}$ Reaction Rates**
SU Jun, LI Zhi-Hong, GUO Bing, BAI Xi-Xiang, LI Zhi-Chang, LIU Jian-Cheng, WANG You-Bao, LIAN Gang, ZENG Sheng, WANG Bao-Xiang, YAN Sheng-Quan, LI Yun-Ju, LI Er-Tao, FAN Qi-Wen, LIU Wei-Ping

(Continued on inside back cover)

JUST FOR POSTERS
— CHINESE PHYSICS LETTERS

- 052501 Emission of Neutral Pions with High Transverse Momenta in A-A and p-p Collisions at Energies Available at the BNL Relativistic Heavy Ion Collider**
FAN San-Hong, MENG Cai-Rong, LIU Fu-Hu
- 052502 Influence of the Nucleon Hard Partons Distribution on J/ψ Suppression in a GMC Framework**
WANG Hong-Min, HOU Zhao-Yu, SUN Xian-Jing
- 052503 Rapidity Losses in Heavy-Ion cCollisions from AGS to RHIC Energies**
ZHOU Feng-Chu, YIN Zhong-Bao, ZHOU Dai-Cui
- 052901 Gallium Nitride Room Temperature α Particle Detectors**
LU Min, ZHANG Guo-Guang, FU Kai, YU Guo-Hao
- 052902 Optimization of Experimental Discharge Parameters to Increase the Arc Efficiency of the Bucket Ion Source**
YU Li-Ming, LEI Guang-Jiu, CAO Jian-Yong, ZHONG Guang-Wu, JIANG Shao-Feng, ZOU Gui-Qing, JIANG Tao, LU Da-Lun, ZHANG Xian-Ming, LIU He
- 052903 Varying Track Etch Rates along the Fission Fragments' Trajectories in CR-39 Detectors**
N. Ali, E. U. Khan, A. Waheed, S. Karim, F. Khan, A. Majeed
- ATOMIC AND MOLECULAR PHYSICS**
- 053201 Chip-Based Square Wave Dynamic Micro Atom Trap**
DAN Lin, YAN Hui, WANG Jin, ZHAN Ming-Sheng
- 053202 A Novel Observation of "a Sharp Absorption Line" Using Much More Broad Laser Lights: Quantum Interference in the Autoionization Spectra of Sc**
ZHONG Zhi-Ping, GAO Xiang, ZHANG Xiao-Le, LI Jia-Ming
- 053401 Collision of Low Energy Proton with Ethylene**
WANG Zhi-Ping, WANG Jing, ZHANG Feng-Shou
- 053701 Ionization Detection of Ultracold Ground State Cesium Molecules**
JI Zhong-Hua, WU Ji-Zhou, MA Jie, FENG Zhi-Gang, ZHANG Lin-Jie, ZHAO Yan-Ting, WANG Li-Rong, XIAO Lian-Tuan, JIA Suo-Tang
- FUNDAMENTAL AREAS OF PHENOMENOLOGY(INCLUDING APPLICATIONS)**
- 054101 Rayleigh Scattering for An Electromagnetic Anisotropic Medium Sphere**
LI Ying-Le, WANG Ming-Jun, DONG Qun-Feng, TANG Gao-Feng
- 054201 Characteristics and New Measurement Method of NCSFs of Individual Color Mechanisms of Human Vision**
GE Jing-Jing, WANG Zhao-Qi, WANG Yan, ZHAO Kan-Xing
- 054202 A Phase-Controlled Optical Parametric Amplifier Pumped by Two Phase-Distorted Laser Beams**
REN Hong-Yan, QIAN Lie-Jia, YUAN Peng, ZHU He-Yuan, FAN Dian-Yuan
- 054203 Broadband Convergence of 40 GHz-ROF and 10-Gb/s WDM-PON Systems in the Duplex Access Network**
ZHANG Li-Jia, XIN Xiang-Jun, LIU Bo, ZHANG Qi, WANG Yong-Jun, YU Chong-Xiu
- 054204 Fabrication and Characterization of High Power InGaN Blue-Violet Lasers with an Array Structure**
JI Lian, ZHANG Shu-Ming, JIANG De-Sheng, LIU Zong-Shun, ZHANG Li-Qun, ZHU Jian-Jun, ZHAO De-Gang, DUAN Li-Hong, YANG Hui
- 054205 A Hybrid Method of Solving the Electromagnetic Inverse Scattering Problem in Lossy Medium**
YANG Xi, ZHANG Yu, GOU Ming-Jiang, SHI Qing-Fan, SUN Gang
- 054206 Wavelength Modulation Absorption Spectroscopy Using a Frequency-Quadruped Current-Modulated System**
SHAO Jie, SUN Hui-Juan, WANG Hui, ZHOU Wei-Dong, WU Gen-Zhu

- 054207 Intensity Spatial Profile Analysis of a Gaussian Laser Beam at Its Waist Using an Optical Fiber System**
ZHANG Liangmin
- 054208 Silicon-Based Asymmetric Add-Drop Microring Resonators with Ultra-Large Through-Port Extinctions**
XIAO Xi, LI Yun-Tao, YU Yu-De, YU Jin-Zhong
- 054209 Measurement of Ultrashort Laser Pulse Width in a Wide Spectrum Range Using Dimethyl Sulfoxide by Optical Kerr Effect Technique**
KONG De-Gui, CHANG Qing, YE Hong-An, GAO Ya-Chen, ZHANG Li-Xin, WANG Yu-Xiao, ZHANG Xue-Ru, YANG Kun, SONG Ying-Lin
- 054210 Synthesis of Fiber Bragg Gratings with Right-Angled Triangular Spectrum**
LI Li-Sha, FENG Xuan-Qi
- 054211 Generation of Sub-2 Cycle Optical Pulses with a Differentially Pumped Hollow Fiber**
ZHANG Wei, TENG Hao, YUN Chen-Xia, ZHONG Xin, HOU Xun, WEI Zhi-Yi
- 054212 Residual Doppler Effect on Electromagnetically Induced Transparency in a Zeeman Sublevel System**
HU Zhen-Yan, LI Lu-Ming, CHEN Pei-Rong, SUN Xin
- 054213 Supercontinuum Generation in InP Nano Inner Cladding Fibers**
DUAN Yu-Wen, ZHANG Ru, WANG Jin, CHEN Xi, ZHONG Kun
- 054301 A Combined Reconstruction Algorithm for Limited-View Multi-Element Photoacoustic Imaging**
YANG Di-Wu, XING Da, ZHAO Xue-Hui, PAN Chang-Ning, FANG Jian-Shu
- 054701 Capillary Rise in a Single Tortuous Capillary**
CAI Jian-Chao, YU Bo-Ming, MEI Mao-Fei, LUO Liang
- 054702 Intermittency and Thermalization in Turbulence**
ZHU Jian-Zhou, Mark Taylor
- 054703 Generation Mechanism of Liquid Column during the Burst of a Rising Bubble near a Free Surface**
WANG Han, ZHANG Zhen-Yu, YANG Yong-Ming, ZHANG Hui-Sheng
- PHYSICS OF GASES, PLASMAS, AND ELECTRIC DISCHARGES**
- 055201 Electron Emission Suppression from Cathode Surfaces of a Rod-Pinch Diode**
GAO Yi, YIN Jia-Hui, SUN Jian-Feng, ZHANG Zhong, ZHANG Peng-Fei, SU Zhao-Feng
- 055202 First Charge Exchange Recombination Spectroscopy Diagnostic in HL-2A Tokamak**
HAN Xiao-Yu, DUAN Xu-Ru, YANG Li-Mei, YU De-Liang, ZHONG Wu-Lv, FU Bing-Zhong, LIU Yong, LIU Yi, YAN Long-Wen, YANG Qing-Wei
- 055203 Characteristics of a Novel Water Plasma Torch**
NI Guo-Hua, MENG Yue-Dong, CHENG Cheng, LAN Yan
- 055204 Propagation Characteristics of Whistler-Mode Chorus during Geomagnetic Activities**
ZHOU Qing-Hua, HE Yi-Hua, HE Zhao-Guo, YANG Chang
- CONDENSED MATTER: STRUCTURE, MECHANICAL AND THERMAL PROPERTIES**
- 056101 Quantitative Characterization of Partial Dislocations in Nanocrystalline Metals**
NI Hai-Tao, ZHANG Xi-Yan, ZHU Yu-Tao
- 056201 Frequency Response of Sample Vibration Mode in Scanning Probe Acoustic Microscope**
ZHAO Ya-Jun, CHENG Qian, QIAN Meng-Lu
- 056801 Temperature-Dependent Raman Spectrum of Hexagonal YMnO₃ Films Synthesized by Chemical Solution Method**
LIU Yue-Feng, WANG Bei, ZHENG Hai-Wu, LIU Xiang-Yang, GU Yu-Zong, ZHANG Wei-Feng

- 056802 Influence of Au-Doping on Morphology and Visible-Light Reflectivity of TiN Thin Films Deposited by Direct-Current Reactive Magnetron Sputtering**
NA Yuan-Yuan, WANG Cong, LIU Yu
- 056803 Research of Equilibrium Composition Map in Conic Quantum Dots**
ZHAO Wei, YU Zhong-Yuan, LIU Yu-Min, FENG Hao, XU Zi-Huan
- 056804 Large-Area Self-Assembly of Rubrene on Au(111) Surface**
LIU Xiao-Qing, KONG Hui-Hui, CHEN Xiu, DU Xin-Li, CHEN Feng, LIU Nian-Hua, WANG Li
CONDENSED MATTER: ELECTRONIC STRUCTURE, ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES
- 057101 Quantum Mechanical Study on Tunnelling and Ballistic Transport of Nanometer Si MOSFETs**
DENG Hui-Xiong, JIANG Xiang-Wei, TANG Li-Ming
- 057102 Spectral Response and Photoelectrochemical Properties of $Cd_{1-x}Zn_xSe$ Films**
N. J. Suthan Kissinger, G. Gnana Kumar, K. Perumal, J. Suthagar
- 057103 Mechanism of Visible Photoactivity of F-Doped TiO_2**
GUO Mei-Li, ZHANG Xiao-Dong, LIANG Chun-Tian, JIA Guo-Zhi
- 057104 Variation of Optical Quenching of Photoconductivity with Resistivity in Unintentional Doped GaN**
HOU Qi-Feng, WANG Xiao-Liang, XIAO Hong-Ling, WANG Cui-Mei, YANG Cui-Bai, LI Jin-Min
- 057201 Thermoelectric Performances of Free-Standing Polythiophene and Poly(3-Methylthiophene) Nanofilms**
LU Bao-Yang, LIU Cong-Cong, LU Shan, XU Jing-Kun, JIANG Feng-Xing, LI Yu-Zhen, ZHANG Zhuo
- 057202 Spin Current Through Triple Quantum Dot in the Presence of Rashba Spin-Orbit Interaction**
LI Jin-Liang, LI Yu-Xian
- 057301 Anomalous Effect of Interface Traps on Generation Current in Lightly Doped Drain nMOS-FET's**
MA Xiao-Hua, GAO Hai-Xia, CAO Yan-Rong, CHEN Hai-Feng, HAO Yue
- 057302 Shape-Controlled Synthesis and Related Growth Mechanism of $Pb(OH)_2$ Nanorods by Solution-Phase Reaction**
CHENG Jin, ZOU Xiao-Ping, SONG Wei-Li, CAO Mao-Sheng, SU Yi, YANG Gang-Qiang, LÜ Xue-Ming, ZHANG Fu-Xue
- 057303 Infrared Absorption Spectra of Undoped and Doped Few-Layer Graphenes**
XU Yue-Hua, JIA Yong-Lei, ZHOU Jian, DONG Jin-Ming
- 057304 Observation of Coulomb Oscillations with Single Dot Characteristics in Heavy Doped Ultra Thin SOI Nanowires**
FANG Zhong-Hui, ZHANG Xian-Gao, CHEN Kun-Ji, QIAN Xin-Ye, XU Jun, HUANG Xin-Fan, HE Fei
- 057305 Blue Luminescent Properties of Silicon Nanowires Grown by Solid-Liquid-Solid Method**
PENG Ying-Cai, FAN Zhi-Dong, BAI Zhen-Hua, ZHAO Xin-Wei, LOU Jian-Zhong, CHENG Xu
- 057306 White Emitting ZnS Nanocrystals: Synthesis and Spectrum Characterization**
HUANG Qing-Song, DONG Dong-Qing, XU Jian-Ping, ZHANG Xiao-Song, ZHANG Hong-Min, LI Lan
- 057501 Microwave Magnetic Properties and Natural Resonance of ϵ -Co Nanoparticles**
YANG Yong, XU Cai-Ling, QIAO Liang, LI Xing-Hua, LI Fa-Shen
- 057502 Effective Anisotropy in Magnetically $Nd_2Fe_{14}B/\alpha$ -Fe Nanocomposite**
GUO Jia-Jun, CHEN Lei, ZHAO Xu, FAN Su-Li, CHEN Wei
CROSS-DISCIPLINARY PHYSICS AND RELATED AREAS OF SCIENCE AND TECHNOLOGY
- 058101 Improvement of AlN Film Quality by Controlling the Coalescence of Nucleation Islands in Plasma-Assisted Molecular Beam Epitaxy**
ZHANG Chen, HAO Zhi-Biao, REN Fan, HU Jian-Nan, LUO Yi

- 058102 Preparation of Functional Gradient Material n-PbTe with Continuous Carrier Concentration**
ZHU Pin-Wen, HONG You-Liang, WANG Xin, CHEN Li-Xue, IMAI Yoshio
- 058103 Deposition Behavior and Mechanism of Ni Nanoparticles on Surface of SiC Particles in Solution Systems**
XU Hui, KANG Yu-Qing, ZHANG Lu, JIN Hai-Bo, WEN Bo, WEN Bao-Li, YUAN Jie, CAO Mao-Sheng
- 058501 A Single Photon Counting Detector Based on One-Dimensional Vernier Anode**
YANG Hao, ZHAO Bao-Sheng, SHENG Li-Zhi, LI Mei, YAN Qiu-Rong, LIU Yong-An
- 058502 Extrinsic Base Surface Passivation in High Speed “Type-II” GaAsSb/InP DHBTs Using an InGaAsP Ledge Structure**
LIU Hong-Gang, JIN Zhi, SU Yong-Bo, WANG Xian-Tai, CHANG Hu-Dong, ZHOU Lei, LIU Xin-Yu, WU De-Xin
- 058901 Detecting Overlapping Communities Based on Community Cores in Complex Networks**
SHANG Ming-Sheng, CHEN Duan-Bing, ZHOU Tao
- 058902 Increase of Traffic Flux in Two-Route Systems by Disobeying the Provided Information**
SUN Xiao-Yan, JIANG Rui, WANG Bing-Hong
- GEOPHYSICS, ASTRONOMY, AND ASTROPHYSICS**
- 059101 Prediction and Elimination of Multiples Based on Energy Flux Conservation Theorem and Prediction Operator Equation**
He Li, LIU Hong, DING Ren-Wei, LI Bo

JUST FOR AUTHORS
— CHINESE PHYSICS LETTERS