Nishina Asia Award 2014年度候補者一覧

ファイル番号	候補者	候補者所属	業績の題目	推薦者	論文査読者 (敬称略)
No.14-1 (13-4)	**Xueqing Yan** 生年月日1977年7月2日 中国	Institute of Heavy Ion Physics,school of physics,Peking University,China	Generating High-Current Monoenergetic Proton Beams by a Circularly Polarized Laser Pulse	**田島　俊樹** IZEST	**伊藤、梶田、山内**
No.14-2 (13-15)	**Hyotherl Ihee** 生年月日 韓国	Professor, Department of Chemistry, KAIST (Korea Advanced Institute of Science and Technology)	For making it possible to study the molecular structural changes and molecular reaction dynamics in the solution phase by advancing ultrafast x-ray liquidgraphy (solution scattering).	**志田　忠正** 京都大学　名誉教授	**家、三島**
No.14-3	**Albert Kong** 生年月日 台湾	Professor, National Tsing Hua University	THE X-RAY SPECTRA OF BLACK HOLE X-RAY NOVAE IN QUIESCENCE AS	**井上　允** 台湾中央研究院　天文及天文物理研究所　特聘研究院	**梶田、永宮、佐々木**
No.14-4	**Yu-ao Chen** 生年月日 中国	Hefei National Laboratory for Physical Sciences at the MicroscaleUniversity of Science and Technology of China (USTC)	For his outstanding achievements in the fields of quantum manipulation of photons and atoms.	**Yidong GU,** Center for Space Utilization, CAS, **Wenlong ZHAN,** Headquarter CAS,	**上田、西森、三島**
No.14-5	**Yoon-Ho Kim** 生年月日 韓国	Pohang University of Science and Technology(POSTECH),Korea	Experimental and theoretical researches on quantum decoherence and quantum measurement,leading to significant new findings on quantum-to-classical transition and decoherence suppression for entangled quantum systems.	**Seunghwan Kim** President,Asia Pacific Center for Theoretical Physics,Pohang,Korea	**上田、前野**
No.13-6	**Yuanbo Zhang** 生年月日 中国	Department of Physics,Fudan University,China	the electronic properties of graphene	**Ruibao Tao** Department in Physics,Fudan University,Shanghai200433,China	**家、西森、前野**
No.13-16	**Hawoong Jeong** 生年月日 韓国	KAIST-Chair Professor / Head of Department, Department of Physics, KAIST (Korea Advanced Institute of Science and Technology)	The large-scale organization of metabolic networks	**Prof Dr. Bongsoo Kim** Affiliation: Department of Physics, Changwon National University, Changwon, Korea	**西森、初田、江口**

Nomination form for the 2014 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree of Ph.D, nationality, address, and telephone)
Name: Xueqing Yan Affiliation: Institute of Heavy Ion Physics, school of physics, Peking University, China Sex: Male Nationality: P.R. China telephone: +86-10-62755023/ +8615010810394 E-mail: **x.yan@pku.edu.cn** Address: No.201, Chengfu Road, Haidian，Beijing, China, 100871 Date of Ph.D Degree: June, 2004
Citation for the Award (Within 30 words) He pioneered in the **Phase Stability Acceleration** in laser-plasma-accelerators, playing the key role obtaining the record-high energies of 30MeV proton and 0.5 GeV-carbon in **PSA experiments**.
Description of the work
Professor Xueqing Yan made fundamental breakthroughs in advancing the laser-driven ion acceleration method. Ultrahigh-intensity lasers can produce accelerating fields of TV/m, surpassing those in conventional accelerators for ions by a 3 orders of magnitude. In spite of this fascinating feature, due to the lack of longitudinal confinement of the ion beam, the laser plasma community has long been hampered that the laser ion acceleration has failed results with an impressive beam quality since the advent of laser ion acceleration experiments reported in the well-known 2000 publications. In order to address this problem, Professor Xueqing Yan was the first (in 2008) to realize the importance of and propose a method to maintain the **Phase Stability Acceleration** in a laser plasma accelerator of protons and ions. This method can accelerate and bunch the proton beams similar to the conventional accelerators, leading to the solution of the above key

issue and excitement in the community (PRL 100, 135003 2008).

Since then Dr. Yan worked at the Max-Planck-Institute for Quantum Optics (MPQ) since September 2008 under an Alexander von Humboldt Research Fellowship. For his outstanding accomplishments, he was granted an extension of stay by the Humboldt Foundation. He further investigated ultra-thin foils irradiated by circularly polarized laser light. This work was the first to show that a GeV mono-energetic proton beam can be generated by the **Phase Stability Acceleration,** now documented in the Physical Review Letters with Dr. Yan as the first author (PRL 103, 135001,2009).

At MPQ he has also strongly contributed to experimental investigations on ion acceleration. These experiments have pioneered the use of ultra-thin (few nanometer thick) target foils and were performed at the laser facilities in Berlin and Los Alamos. Dr. Yan played a key role in these successfully experiments, demonstrating 30MeV carbon/proton (peak energy) acceleration (PRL 103, 245003 (2009)) and half GeV carbon (cut off energy) acceleration (Nucl. Fusion 51 (2011)). **Both were the records in energies until 2013**. **This is a break-through in laser-driven ion acceleration, a great milestone for the laser driven ion accelerator research**.

The Phase Stability Acceleration is very efficient for ion acceleration. However, it requires an ultra-high intensity as well as an ultra-high contrast laser pulse with steep front. These are quite challenging for the state-of-the-art laser technology. To ameliorate this challenge, he further proposed to use **near critical density plasma as a laser plasma lens** located in front of a thin foil **[**PRL 107, 265002 (2011)]. This cleans the laser pulse and enhances the laser intensity by one order of magnitude. The proof-of-principle experiment was carried out recently (J. Bin et al. arXiv: 1402.4301) at RAL by using nanotube layer of 1~5 micron thickness, showing the carbon energy enhanced from 72MeV to 210MeV. This wonderful idea should break a new ground and lead to many more advanced experiments to come.

Key references (up to 3 key publications)

1. X. Q. Yan, C. Lin, Z. M. Sheng, Z. Y. Guo, B. C. Liu,Y. R. Lu, J. X. Fang, and J. E. Chen，High current and monoenergetic proton beams generated by a circularly-polarized laser pulse in the phase-stable acceleration (PSA) regime, Phys. Rev. Lett. **100,** 135003 (2008).

2. X. Q. Yan, H. C. Wu, Z. M. Sheng, J. E. Chen and J. Meyer-ter-Vehn,

Self-organizing GeV nano-Coulomb collimated proton beam from laser foil interaction at 7 × 10^{21} W/cm^2, Phys. Rev. Lett. **103,** 135001 (2009).

3.H.Y.Wang, C. Lin, Z. M. Sheng, B. Liu, S. Zhao, Z.Y. Guo, Y. R. Lu, X. T. He, J. E. Chen, and X. Q Yan, Laser Shaping of a Relativistic Intense, Short Gaussian Pulse by a Plasma Lens, Phys. Rev. Lett. **107**, 265002 (2011).

*copy of one most significant publication should be attached

Nominator (name, affiliation, email, telephone, and relation to the candidate)

Name: Toshiki Tajima
Affiliation: University of California at Irvine
Email: ttajima@uci.edu
Telephone: +1-562-371-7249
relation to the candidate: the former colleague/supervisor at MPQ

Signature Date March 19, 2014

Nomination form for the 2013 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree of Ph.D, nationality, address, email and telephone)
Hyotcherl Ihee, Professor, Department of Chemistry, KAIST (Korea Advanced Institute of Science and Technology) *Curriculum vitae including the date of the degree of Ph.D, nationality, address, email and telephone is attached as a separate file.
Citation for the Award (within 30 words)
For making it possible to study the molecular structural changes and molecular reaction dynamics in the solution phase by advancing ultrafast x-ray liquidgraphy (solution scattering).
Description of the work
The term liquidgraphy coined by the candidate is a new methodology to observe structural changes of molecules undergoing photo-induced chemical reactions in liquids. The understanding of such dynamical processes in the liquid phase on an atomic and molecular level is a paramount target of fundamental chemistry since the vast majority of chemical and biochemical processes proceed in liquids. However, complex interactions between solute and solvent defy detailed studies compared with the study in gas phase. So far, for tracking of time-dependent processes, whether in gas or in solution, time-resolved optical absorption and emission spectroscopic methods have been developed which, however, have failed to provide direct information on *molecular structural changes* such as the bond lengths and bond angles. In order to resolve this problem, Ihee and his team developed a "camera" to shoot ultrafast X-ray diffraction patterns of solution (i.e., liquidography). This is a direct technique to probe structural dynamics for chemical processes *in solution*. The visualizing power and unbiased sensitivity of X-ray scattering proved to be instrumental in identifying global reaction pathways and in some cases capturing detailed three dimensional structures of ephemeral reaction intermediates. Their technique to provide direct structural information is in sharp contrast to conventional ultrafast optical spectroscopy, which is difficult to provide time dependence of bond lengths and angles of all molecular species involved in dynamic processes over a wide range of times, i.e., from picoseconds to milliseconds. Using the technique, they have studied structural dynamics and spatiotemporal kinetics of many molecular systems including diatomic molecules, alkyl halides, organometallic complexes, and protein molecules. The choice of the above molecules is not at all capricious. These molecules have been

Nomination form for the 2014 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree of Ph.D., nationality, address, email and telephone)
Name: Albert Kong Affiliation: National Tsing Hua University, Taiwan Nationality: Hong Kong/Taiwan Address: Institute of Astronomy, National Tsing Hua University, 101, Section 2, Kuang-Fu Road, Hsinchu 30013, Taiwan Email: akong@phys.nthu.edu.tw Phone: +886-35742619 Current Position: Professor, National Tsing Hua University, 8/2011 – present Positions Held: Honorary Associate Professor, The University of Hong Kong, 4/2011 - present Associate Professor, National Tsing Hua University, Taiwan, 8/2007 - 7/2011 Post-doctoral Associate, Massachusetts Institute of Technology, 2/2005 - 8/2007 Post-doctoral Research Fellow, Harvard-Smithsonian Center for Astrophysics, 11/2000 - 1/2005 Education: D.Phil., Oxford University, United Kingdom, 2001 M.Phil., The University of Hong Kong, Hong Kong, 1997 B.Sc., The Hong Kong Polytechnic University, Hong Kong, 1995 Awards: 2013: Academia Sinica Research Award for Junior Research Investigators 2011-2014: National Science Council Outstanding Young Researcher Program 2008-2012: Kenda Foundation Golden Jade Fellow 2008: University Junior Researcher Award 2001-2003: Croucher Fellowship

Citation for the Award (within 30 words)
For the excellent contributions to observational high-energy astronomy, including studies of binary systems involving black holes, neutron stars, and white dwarfs, and a coordination of the Fermi Asian Network.

Description of the work

The candidate has a broad spectrum of research interests in modern astronomy. He has made substantial contributions to multi-wavelength study of X-ray binaries and understanding exotic high-energy sources, and is an extremely productive researcher in high-energy astrophysics. One of his most significant researches is the study of the X-ray spectra of black hole binary systems (Kong et al. 2002, ApJ, 570, 277; one of the key publications, and attached). For many years, the extremely low-level X-ray emission of black hole binaries have been difficult to be explained by standard accretion model. One solution is that all the infalling material is lost from view as it falls through the black hole event horizon. Using the most powerful X-ray telescope, he showed confidently that the weak X-ray emission of black hole binaries is due to the event horizon, and ruled out other possibilities. He also demonstrated that the X-ray emission of neutron star binaries is higher than that of black hole systems, providing strong evidence of black hole event horizons.

He then further explores the high-energy stellar populations of nearby galaxies with a focus on studying the nature of the most luminous X-ray sources. These luminous X-ray sources are not known in our Milky Way and may represent the long-sought intermediate-mass black holes. He has been leading the search for intermediate-mass black holes and has published a series of papers.

In the past few years, his research focuses on multi-wavelength (from GHz to GeV) studies of compact objects. In particular, with the launch of the Fermi Gamma-ray Space Telescope (Fermi) in mid-2008, we have entered a new era of high-energy astrophysics. In early 2010, he discovered gamma-ray emission from a well-studied globular cluster (GC), Terzan 5 (Kong, Hui & Cheng 2010 ApJ, 712, L36), the second gamma-ray emitting GC and this is also the first Fermi discovery paper written by a non-NASA led Fermi team. In this paper, not only we expect that there will be more GCs detected by Fermi in the near future, he also propose several gamma-ray emission models to explain the observations. Shortly after this paper, more than ten GCs have been detected in gamma-ray by his team (Tam et al. 2011, ApJ, 729, 90) and the Fermi team. In a companion paper, they have developed a theoretical model to explain the gamma-ray emission of GCs (Cheng et al. 2010, ApJ, 723, 1219). Furthermore, they investigate the relationship between different physical properties of GCs and their gamma-ray emission (Hui et al. 2011, ApJ, 726, 100). These answer some of the key questions about the origin of millisecond pulsars. Motivated by this paper, he initiated a Fermi Asian Network to promote Fermi science in Asia. Through gathering a group of high-energy astrophysicists in the East Asian region, he coordinates the collaboration on all research efforts. They have made significant contributions in terms of number of publications (since 2010 they have published more than 20 Fermi-related ApJ papers) and regional educational activities for the community. His team has been working on various different aspects in gamma-ray astronomy including pulsars, novae, unidentified gamma-ray sources, and supernova remnants.

Part of his recent research is devoted to transient astronomical phenomena in the universe. By definition, transient means a “new” star in the sky and its brightness is changing through time. It is very common that this object will appear in the sky for a short time and then disappears (for example, supernova explosion). Therefore monitoring observations and rapid follow-up are required to study their nature. His group is interested in following up newly discovered transients with X-ray and optical telescopes. In 2008, he is one of the three astronomers who discovered the first ever X-ray outburst at the moment of a supernova explosion (Soderberg et al. 2008, Nature, 453, 469). Last year, after a discovery of a strong but short-lived X-ray flare from the Small Magellanic Cloud, his team made use of the Swift space telescope to observe this event. He followed the events for two weeks and based on the X-ray spectra obtained from the Swift telescope, the low-temperature thermal X-ray emission is likely the consequence of thermonuclear burning of hydrogen on the surface of a white dwarf. In collaboration with astronomers from UK, South Africa, Poland, Italy, and Australia, they used ground-based telescopes in Chile, South Africa, and Australia to perform a series of follow-up observations. They showed that the object was a white dwarf orbiting a hot, massive (10 solar masses) star in the Small Magellanic Cloud (Li et al. 2012, ApJ, 761, 99). This white dwarf plus massive star combination is a very rare binary system and only two had been seen before but with much lower X-ray luminosities. The observations revealed that when the white dwarf was orbiting around the massive star, it pulled matters from the massive star to the surface of the white dwarf. When sufficient material accumulated on its surface, it underwent runaway thermonuclear burning that was seen on Earth as a nova explosion. This thermonuclear burning ejected a shell of material and interacted with the stellar wind from the massive star producing a huge shock to generate the luminous X-ray flash. This was something that has never been seen before. Since the X-ray luminosity of this rare binary system is very similar to that of many black hole binary systems, such a discovery will lead us to rethink other black hole candidates in nearby galaxies and they may in fact belong to a whole new class of white dwarf binaries.

Key references (up to 3 key publications*)

Kong, A. K. H. et al. 2002, "The X-Ray Spectra of Black Hole X-Ray Novae in Quiescence as Measured by Chandra", The Astrophysical Journal, Volume 570, 277

Kong, A. K. H., Hui, C. Y., Cheng, K. S. 2010, "Fermi Discovery of Gamma-ray Emission from the Globular Cluster Terzan 5", The Astrophysical Journal Letters, Volume 712, L36

Kong, A. K. H. et al. 2012, "Discovery of an Unidentified Fermi Object as a Black Widow-like Millisecond Pulsar", The Astrophysical Journal Letters, Volume 747, L3

*) Copy of one most significant publication should be attached.

The first paper is attached.

Nominator (name, affiliation, email, telephone and relation to the candidate)
Name: Inoue, Makoto Affiliation: Academia Sinica Institute of Astronomy and Astrophysics, Taiwan Email: inoue@asiaa.sinica.edu.tw Phone: +886-2-2366-5421 Relation to the candidate: As high energy astronomers in Taiwan, we know well with each other.
Signature Date 21 March 2014

The Astrophysical Journal, 570:277–286, 2002 May 1

THE X-RAY SPECTRA OF BLACK HOLE X-RAY NOVAE IN QUIESCENCE AS MEASURED BY *CHANDRA*

Albert K. H. Kong, Jeffrey E. McClintock, Michael R. Garcia, and Stephen S. Murray
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

and

Didier Barret
Centre d'Etude Spatiale des Rayonnements, 9 Avenue du Colonel Roche, Toulouse 31028, France
Received 2001 October 22; accepted 2002 January 7

ABSTRACT

We present *Chandra* observations of black hole X-ray novae V404 Cyg, A0620−00, GRO J1655−40, and XTE J1550−564 in quiescence. Their quiescent spectra can be well fitted by a power-law model with number slope $\alpha \sim 2$. While a coronal (Raymond-Smith) model is also a statistically acceptable representation of the spectra, the best-fit temperatures of these models is ∼5 times higher than that seen in active stellar coronae. These four spectra of quiescent X-ray novae are all consistent with that expected for accretion via an advection-dominated accretion flow and inconsistent with that expected from a stellar corona. This evidence for continued accretion in quiescence further strengthens the case for the existence of event horizons in black holes. Both A0620−00 and GRO J1655−40 were fainter than in previous observations, while V404 Cyg was more luminous and varied by a factor of 2 in a few kiloseconds. A reanalysis of the X-ray data for XTE J1550−564 shows that (like V404 Cyg and A0620−00) its luminosity exceeds the maximum prediction of the coronal model by a large factor. The 0.3–7 keV luminosities of the four sources studied are in the range from $\sim 10^{30}$ to 10^{33} ergs s^{-1}.

Subject headings: black hole physics — stars: individual (A0620−00, GRO J1655−40, V404 Cygni, XTE J1550−564) — X-rays: binaries

1. INTRODUCTION

X-ray novae (XNs) are compact binary systems in which a Roche lobe overflowing main-sequence or subgiant star, typically $\sim 1\ M_\odot$, transfers matter onto a black hole (BH) or neutron star (NS) primary (for a review, see van Paradijs & McClintock 1995; Tanaka & Lewin 1995; Tanaka & Shibazaki 1996). XNs are highly variable and undergo rare but dramatic X-ray and optical outbursts. For most of the time, XNs are in a quiescent state and are very faint. During quiescence, the mass accretion rate from the disk to the compact object may be very small, producing a low-level (perhaps no) X-ray emission. X-ray observations of quiescent XNs have been hindered due to the limited sensitivity of previous X-ray telescopes. Nonetheless, several of the brightest black hole X-ray novae (BHXNs) have been detected with *ROSAT*, *ASCA*, and *BeppoSAX*. This quiescent X-ray (and associated nonstellar optical) emission is difficult to explain using standard accretion-disk models. Narayan, McClintock, & Yi (1996), Narayan, Barret, & McClintock (1997a), and Narayan, Garcia, & McClintock (2001) showed that the observations can be explained by an advection-dominated accretion flow (ADAF) model.

An ADAF is an accretion flow in which most of the energy is stored in the accreting gas rather than being radiated away promptly, as in a thin accretion disk. This thermal energy is advected with the flow to the center—hence the name ADAF. If the accretor is a BH, the gas with all its thermal energy will be lost from view as it falls through the event horizon. However, in the case of a NS, the accretion energy will eventually be radiated from the star's surface. This difference can explain the fact that quiescent BHs are much fainter than quiescent NSs. Using pre-*Chandra* data, Narayan, Garcia, & McClintock (1997b) showed that BHs display a large variation of luminosity between their bright and their faint states, while NSs have a much smaller variation. Menou et al. (1999) subsequently pointed out that in comparing the luminosities of BH and NS systems, it is important to compare systems with comparable orbital periods. More recently, Garcia et al. (2001, hereafter G01) presented a comprehensive study of a series of *Chandra* observations of BHXNs in quiescence; they confirmed that the quiescent X-ray luminosities of BHXNs are ∼100 times lower than those of neutron star X-ray novae (NSXNs). Such findings provide strong evidence that BHs have event horizons.

Recently, Bildsten & Rutledge (2000) suggested that the rapidly rotating secondaries of BHXNs may generate stellar coronae with sufficient X-ray luminosity to account for the observed quiescent luminosities of many of these systems. Based on an analogy to the "saturated" coronae in the most luminous RS CVn stars, the coronae in quiescent BHXNs are predicted to have maximum luminosities of 0.1% of the stellar bolometric luminosity and X-ray spectra that are typical of moderately hot ($kT \lesssim 1$ keV), optically thin thermal plasmas. While the X-ray luminosity of V404 Cyg is too high to be produced by a stellar corona, previous observations with modest sensitivity have indicated that the luminosities of other BHXNs are consistent with a saturated corona (Bildsten & Rutledge 2000). For these systems, the high signal-to-noise ratio X-ray spectra attainable with *Chandra* and *XMM-Newton* can provide a critical test of the possible coronal origin of the quiescent X-ray luminosity (Bildsten & Rutledge 2000; Lasota 2000).

In this paper, we report the detailed analysis of *Chandra* spectra of the three brightest quiescent BHXNs observed under an AO-1 Guaranteed Time observer (GTO) program (V404 Cyg, A0620−00, and GRO J1655−40). We also reanalyzed the spectrum of a fourth BHXN (XTE J1550−564) observed under a Director's Discretionary Time proposal. We note that three other BHXNs (GRO J0422+32, GS 2000+25, and 4U 1543−47) observed under our AO-1 GTO and General Observer programs provided insufficient counts for spectral analysis. We briefly describe previous quiescent observations of these four sources in § 2. In § 3 we outline our analysis procedure and report the results in § 4. The results are discussed in § 5.

2. PREVIOUS QUIESCENT X-RAY OBSERVATIONS

All four BHXNs have been observed previously in the X-ray, and a summary of previous quiescent observations is given in Table 1; here we discuss them briefly.

V404 Cyg.—This relatively bright quiescent BHXN has previously been observed by *ROSAT*, *ASCA*, and *BeppoSAX* (see Table 1). In general, the X-ray spectrum can be fitted by a power-law model with photon index $\alpha \sim 2$ and $N_H \sim (1\text{–}2) \times 10^{22}$ cm^{-2}; the luminosity is $\sim 10^{33}$ ergs s^{-1} (Narayan et al. 1997a). We also note that the quiescent source flux can vary on short timescales. Wagner et al. (1994) reported that V404 Cyg decreased in intensity by a factor of 10 in less than 0.5 days and showed variability by a factor of ~2 on timescales of ~30 minutes.

A0620−00.—This source was observed by *ROSAT* in 1992 during its quiescent state (McClintock, Horne, & Remillard 1995; Narayan et al. 1997a). The 39 ± 8 counts detected allowed only a modest estimate of the source spectrum. Simple one-component models fit the spectrum equally well: for example, a power law with $\alpha \sim 3.5$ and $N_H = (0.1\text{–}1) \times 10^{22}$ cm^{-2} or a blackbody with $kT = 0.16^{+0.10}_{-0.05}$ keV. The luminosity is $\sim 5 \times 10^{30}$ ergs s^{-1}. An *ASCA* observation in 1994 March failed to detect the source; a 3 σ upper limit on the luminosity was 8×10^{30} ergs s^{-1} (Asai et al. 1998).

GRO J1655−40.—The only quiescent observation of GRO J1655−40 was taken in 1996 March with *ASCA* (Ueda et al. 1998; Asai et al. 1998). The spectrum can be fitted by a power-law model with a photon index $\alpha \sim 0.7$ and $N_H < 3 \times 10^{21}$ cm^{-2}; the source luminosity is 3×10^{32} ergs s^{-1} in 0.5–10 keV. However, we note that this observation was taken between two outbursts separated by ~1 yr, and therefore it may not represent the true quiescent emission.

XTE J1550−564.—This microquasar system was observed as a DDT program on 2000 August 21 and 2000 September 11, which were less than 120 days after the peak of the 2000 outburst of the source; a detailed spectral analysis has already been given by Tomsick, Corbel, & Kaaret (2001). The energy spectrum can be fitted by an absorbed power-law spectrum with $\alpha = 2.3^{+0.41}_{-0.48}$ and $N_H = (8.5^{+2.2}_{-2.4}) \times 10^{21}$ cm^{-2}; the mean luminosity (0.5–7 keV) is about 6.7×10^{32} ergs s^{-1}.

3. *CHANDRA* OBSERVATIONS AND DATA REDUCTION

V404 Cyg.—*Chandra* observed V404 Cyg on 2000 April 26 for a total of 10,295 s. Our observations cover spectroscopic phases 0.44–0.46 (Casares & Charles 1994), where phase zero corresponds to the closest approach of the secondary star. The source was positioned on the ACIS-S3 CCD with an offset of 40″ from the nominal pointing for the S3. The data were collected using a $\frac{1}{4}$ subarray mode, which boosted the time resolution to 1.14 s. The CCD temperature was −120°C. Standard pipeline-processed level 2 data were used for the analysis. V404 Cyg was clearly detected, and the source position is $\alpha = 20^{h}24^{m}03^{s}.82$, $\delta = +33°52'02''.14$ (J2000.0), which is in good agreement with the optical and radio position of V404 Cyg (Wagner et al. 1991).

The *Chandra* detectors are known to experience periods of high background, which are particularly significant for the S3 chip (e.g., Garcia et al. 2000). We searched for such background flares in our data by examining the light curve of the entire S3 chip minus the source regions. We found that the background was very stable during the whole observation with an average count rate of 0.13 counts s^{-1}. In order to reduce the background, we only analyzed data from 0.3–7 keV. We extracted data from a circle of 3 pixels (~1″.5) centered on V404 Cyg and background from an annulus with inner and outer radii of 10 and 50 pixels, respectively. There were 1587 counts in the source region, and the expected number of background counts in the source region was only 0.4 counts.

A0620−00.—This source was observed by *Chandra* on 2000 February 29 for 44,000 s. ACIS-S was operated in the standard configuration with a time resolution of 3.24 s. A0620−00 was observed on the S3 chip with a 40″ offset

TABLE 1

Previous Quiescent Observations of Black Hole X-Ray Novae

Source	Date	Instrument	N_H (10^{22} cm^{-2})	α	Luminosity (10^{33} ergs s^{-1})	Distance (kpc)	References
V404 Cyg	1992 Nov	*ROSAT*	2.29*	6*	8.1 (0.1–2.4 keV)	3.5	1
V404 Cyg	1992 Nov	*ROSAT*	2.1*	$4.0^{+1.9}_{-1.5}$	1.1 (0.7–2.4 keV)	3.5	2
V404 Cyg	1994 May	*ASCA*	$1.1^{+0.3}_{-0.4}$	$2.1^{+0.5}_{-0.3}$	1.20 (1–10 keV)	3.5	3
V404 Cyg	1996 Sep	*BeppoSAX*	1.0 (fixed)	$1.9^{+0.6}_{-0.3}$	1.04 (1–10 keV)	3.5	4
A0620−00	1992 Mar	*ROSAT*	0.16 (fixed)	$3.5^{+0.8}_{-0.7}$	0.004 (0.4–1.4 keV)	1.0	2
A0620−00	1994 Mar	*ASCA*	1.6 (fixed)	2 (fixed)	<0.008 (0.5–10 keV)	1.0	5
GRO J1655−40	1996 Mar	*ASCA*	<0.3	$0.7^{+2.1}_{-0.4}$	0.3 (0.5–10 keV)	3.2	5
XTE J1550−564.......	2000 Aug & Sep	*Chandra*	$0.85^{+2.2}_{-2.4}$	2.3 ± 0.4	0.67 (0.5–7 keV)	2.5–6.3	6, 7

Note.—The asterisk (*) denotes uncertainty not given. For XTE J1550−564, the luminosity is based on a distance of 4 kpc.

References.—(1) Wagner et al. 1994; (2) Narayan et al. 1996; (3) Narayan et al. 1997a; (4) Campana, Parmar, & Stella 2001; (5) Asai et al. 1998; (6) Tomsick et al. 2001; (7) Orosz et al. 2002.

from the nominal pointing. The background was examined; only intervals in which the source-free count rate was less than 0.15 counts s^{-1} were selected for analysis. The total net exposure time was 41,189 s. The source position is $\alpha = 06^h22^m44^s.48$, $\delta = -00°20'46''.36$ (J2000.0), which is consistent with the optical position (Liu, van Paradijs, & van den Heuvel 2001). The observations cover spectroscopic phases 0.09–1.67 (Orosz et al. 1994; Leibowitz, Hemar, & Orio 1998). Only data from 0.3–7 keV were used for spectral analysis. We extracted data from a circle of $1''.86$ centered on A0620−00. This relatively large aperture encompasses all the counts in the central region that might reasonably be attributed to the source. There were 137 counts in the source region. The background counts in a $1''.86$ aperture are estimated to be 1.2. This small background level was not subtracted.

GRO J1655−40.—*Chandra* observed GRO J1655−40 on 2000 July 1 for 43,000 s, which corresponds to spectroscopic phases of 0.49–0.68 (van der Hooft et al. 1998). The source was located on ACIS-S3 with a 40″ offset from the aim point; standard 3.24 s frame transfer time was employed. Good data were selected with a background count rate less than 0.15 counts s^{-1}, resulting in a net exposure of 42,506 s. GRO J1655−40 was very faint; by filtering the data from 0.3–7 keV and applying a circular extraction region of $1''.41$ centered on the source, only 66 counts were collected. This choice of aperture encompasses all the counts in the central region that are attributable to the source. The estimated background counts in a $1''.41$ aperture are estimated to be 0.7; this background was not subtracted. The Chandra source position is $\alpha = 16^h54^m00^s.09$, $\delta = -39°50'45''.37$ (J2000.0), which is consistent with the radio and optical position (Hjellming 1994; Bailyn et al. 1995).

XTE J1550−564.—The source was observed on 2000 August 21 for ∼5000 s and 2000 September 11 for an additional ∼5000 s; the observations cover spectroscopic phases 0.06–0.11 and 0.63–0.68, respectively (Orosz et al. 2002). Technical details of the observations can be found in Tomsick et al. (2001). We used procedures similar to those outlined in Tomsick et al. (2001) to reduce the data. However, we extracted data from 0.3–7 keV and used a smaller circular extraction region with a radius of 2″, which is sufficient to encompass all the counts in the central region. There are 66 and 109 counts in the first and the second observations, respectively; we ignored the background counts in the source region, which we estimated to be 0.2 counts for the first observation and 0.3 counts for the second observation .

4. SPECTRAL ANALYSIS

4.1. *V404 Cyg*

Spectra were extracted with CIAO Version 2.1[1] and were analyzed with XSPEC Version 11[2] and also SHERPA Version 2.1.2.[3] The results from both analysis systems were consistent, and we report the XSPEC results herein. In order to allow χ^2 statistics to be used, all the spectra were grouped into at least 30 counts per spectral bin. Response files were selected according to the CCD temperature with standard CIAO routines. We fitted the data with several single-component spectral models with interstellar absorption, including power-law, thermal bremsstrahlung, Raymond-Smith, and blackbody models. The best-fit parameters determined by these fits are shown in Table 2.

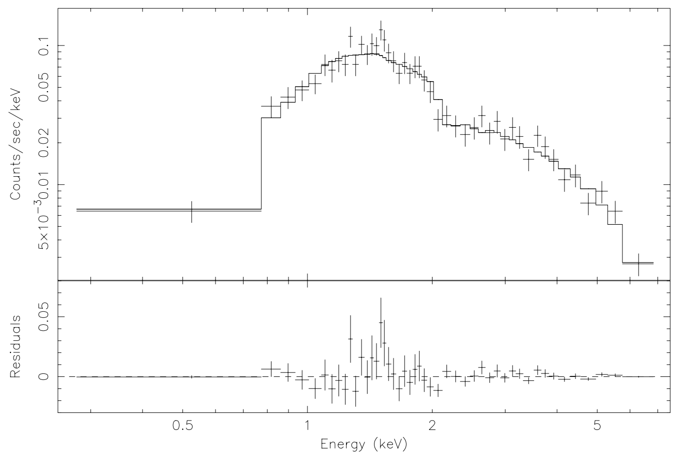

FIG. 1.—*Top*: *Chandra* spectrum of V404 Cyg with an absorbed power-law model ($\alpha = 1.81$ and $N_H = 6.98 \times 10^{21}$ cm^{-2}). *Bottom*: Residuals after subtracting the fit from the data in units of 1 σ.

All models except the blackbody model give statistically acceptable fits to the data ($\chi^2/\nu \lesssim 1$). The power-law model provides the best fit, and yields parameters consistent with previous observations (e.g., $\alpha = 1.81 \pm 0.14$; see Table 1). This best-fitting model is shown in Figure 1, and the corresponding plot of confidence regions for column density (N_H) and photon index (α) are shown in Figure 2 (*left*). The confidence bounds for the Raymond-Smith model are shown in Figure 2 (*right*). The best-fit temperature for this model is $kT = 7.5$ keV, and the 90% lower limit on the temperature is $kT > 6.1$ keV.

The hydrogen column density for V404 Cyg from optical observations was estimated to be 5.4×10^{21} cm^{-2} ($A_V = 3.1$; Casares & Charles 1994). The best-fit values for N_H from the power law and bremsstrahlung models are marginally higher than the optically determined value, but this does not necessarily argue against these models. X-ray binaries often show absorption in the X-ray flux that is somewhat higher than that determined by their optical absorption (Garcia 1994; Vrtilek et al. 1991).

In order to test whether the optically determined absorption yields an acceptable X-ray spectral fit, we reran the fits with the absorption fixed to this value. The results of these fits are also given in Table 2. Even though this N_H value is outside the 99% confidence bounds shown in Figure 2, these fits do yield acceptable values of χ^2/ν (except for the blackbody model). This is a reflection of the fact that the minimum value of χ^2/ν obtained with N_H as a free parameter is slightly less than 1, thereby allowing points outside the $\chi^2_{min} + 9.21$ (Lampton, Margon, & Bowyer 1976) contour to have $\chi^2/\nu \sim 1$. For these fits with N_H fixed, the best-fit temperature for the Raymond-Smith model is raised to 8.9 keV, and the 90% lower limit is raised to more than 7.2 keV.

We do not see any significant Fe K line emission between 6.4–7 keV, with a 90% confidence upper limit of ∼800 eV (line width fixed at 0.1 keV) on the equivalent width.

[1] Available at http://asc.harvard.edu/ciao.
[2] Available at http://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/index.html.
[3] Available at http://asc.harvard.edu/ciao/download/doc/sherpa_html_manual/index.html.

TABLE 2

Best-fitting Spectral Parameters

Model	N_H (10^{21} cm^{-2})	α	kT/kT_{RS}[a] (keV)	χ^2_ν/dof (Probability)	CASH[b] (M-C Probability)	Flux[c]
			V404 Cyg			
Power-law	6.98 ± 0.76	1.81 ± 0.14	...	0.92/45 (0.63)	...	1.42
Bremsstrahlung	$6.04^{+0.60}_{-0.55}$	...	$6.68^{+2.49}_{-1.50}$	0.94/45 (0.57)	...	1.40
Raymond-Smith	$5.82^{+0.56}_{-0.50}$	...	$7.54^{+2.70}_{-1.43}$	1.11/45 (0.28)	...	1.57
Blackbody	2.30 ± 0.42	...	0.81 ± 0.04	2.09/45 (0.00002)	...	1.26
Power-law	5.40 (fixed)	1.55 ± 0.07	...	1.20/46 (0.17)	...	1.47
Bremsstrahlung	5.40 (fixed)	...	8.66 ± 2.13	1.0/46 (0.46)	...	1.42
Raymond-Smith	5.40 (fixed)	...	8.89 ± 1.57	1.13/46 (0.25)	...	1.57
Blackbody	5.40 (fixed)	...	0.69 ± 0.03	3.49/46 (10^{-14})	...	1.15
			A0620−00			
Power-law	$2.37^{+1.14}_{-1.04}$	2.19 ± 0.50	...	0.71/11 (0.73)	0.78	0.018
Bremsstrahlung	$1.52^{+0.72}_{-0.67}$	...	$3.11^{+3.59}_{-1.17}$	0.75/11 (0.69)	0.74	0.018
Raymond-Smith	$1.05^{+0.57}_{-0.50}$	...	$5.46^{+6.51}_{-2.07}$	1.03/11 (0.42)	0.48	0.022
Blackbody	0[d]	...	$0.57^{+0.06}_{-0.07}$	1.58/11 (0.10)	0.10	0.017
Power-law	1.94 ± 0.28 (fixed)	$2.07^{+0.28}_{-0.19}$	...	0.71/12 (0.74)	0.75	0.018
Bremsstrahlung	1.94 ± 0.28 (fixed)	...	$2.55^{+1.44}_{-0.73}$	0.78/12 (0.67)	0.68	0.016
Raymond-Smith	1.94 ± 0.28 (fixed)	...	$4.15^{+2.66}_{-1.30}$	1.38/12 (0.17)	0.14	0.023
Blackbody	1.94 ± 0.28 (fixed)	...	0.30 ± 0.03	2.39/12 (0.004)	0.00	0.009
			GRO J1655−40			
Power-law	$8.59^{+6.19}_{-4.52}$	$1.70^{+0.88}_{-0.78}$	...	0.83/9 (0.59)	0.66	0.017
Bremsstrahlung	$7.72^{+5.11}_{-3.46}$	...	$8.40^{+\infty}_{-5.73}$	0.83/9 (0.58)	0.66	0.016
Raymond-Smith	$7.18^{+4.23}_{-2.97}$	...	$12.24^{+\infty}_{-8.61}$	0.85/9 (0.56)	0.63	0.019
Blackbody	$3.03^{+3.47}_{-2.13}$	...	$0.88^{+0.29}_{-0.18}$	0.94/9 (0.49)	0.57	0.012
Power-law	6.66 ± 0.57 (fixed)	1.47 ± 0.40	...	0.75/10 (0.67)	0.60	0.016
Bremsstrahlung	6.66 ± 0.57 (fixed)	...	$13.21^{+\infty}_{-8.98}$	0.75/10 (0.68)	0.64	0.015
Raymond-Smith	6.66 ± 0.57 (fixed)	...	$17.15^{+\infty}_{-11.35}$	0.77 /10 (0.65)	0.62	0.018
Blackbody	6.66 ± 0.57 (fixed)	...	$0.76^{+0.14}_{-0.12}$	1.07/10 (0.38)	0.39	0.012
			XTE J1550−564			
Power-law	$8.73^{+2.42}_{-2.93}$	$2.28^{+0.47}_{-0.64}$	...	1.27/13 (0.22)	0.22	0.16
Bremsstrahlung	$6.93^{+2.13}_{-1.85}$	...	$3.36^{+4.75}_{-1.33}$	1.26/13 (0.23)	0.24	0.15
Raymond-Smith	$6.50^{+1.97}_{-1.62}$	...	$4.38^{+4.31}_{-1.57}$	1.22/13 (0.25)	0.21	0.18
Blackbody	$3.04^{+1.80}_{-1.49}$	...	$0.69^{+0.11}_{-0.09}$	1.39/13 (0.16)	0.18	0.14
Power-law	3.90 ± 0.60 (fixed)	1.35 ± 0.25	...	1.68/14 (0.05)	0.02	0.17
Bremsstrahlung	3.90 ± 0.60 (fixed)	...	$12.56^{+\infty}_{-7.18}$	1.59/14 (0.07)	0.04	0.15
Raymond-Smith	3.90 ± 0.60 (fixed)	...	$10.31^{+\infty}_{-5.16}$	1.61/14 (0.07)	0.03	0.16
Blackbody	3.90 ± 0.60 (fixed)	...	$0.65^{+0.08}_{-0.06}$	1.39/14 (0.15)	0.15	0.12

Note.—All quoted uncertainties are 90% confidence. Except for V404 Cyg, the best-fit parameters and uncertainties are based on CASH statistics. The reduced χ^2 values were obtained in a separate analysis using χ^2 statistics.

[a] Thermal bremsstrahlung, blackbody, or Raymond-Smith temperatures (solar abundance).

[b] For A0620−00, GRO J1655−40, and XTE J1550−564, we list 1 minus the probability that the best-fit model will produce a lower value of the CASH statistic than that calculated from the data, as determined via XSPEC Monte Carlo simulations. A low entry indicates a poor fit.

[c] Absorbed flux in 0.3–7 keV (10^{-12} ergs cm^{-2} s^{-1}).

[d] The value of N_H hit the minimum of 0 allowed by XSPEC.

4.2. *A0620−00*

We analyzed the energy spectrum of A0620−00 using procedures similar to those discussed above for V404 Cyg. We grouped the data into spectral bins containing at least 10 counts and used both χ^2 and CASH (Cash 1979) statistics to estimate the best-fit parameters and their errors. We chose to bin the data in order to achieve enough counts per bin to employ χ^2 statistics. However, binning the data heavily can result in a loss of spectral information. One can also apply the Gehrels' approximation (Gehrels 1986) to permit the use of fewer counts (≤ 5) per bin, but this approach overestimates the errors. CASH statistics is a maximum-likelihood method designed to estimate the best-fit parameters using unbinned or slightly binned data. This is particularly useful when the source yields only very few photons. The disadvantage of CASH statistics relative to χ^2 statistics is that they do not provide a goodness-of-fit criterion for comparing different models. It is therefore worthwhile to examine the results obtained using both χ^2 and CASH statistics. In Table 2, except for V404 Cyg, all the best-fit parameters and errors are based on CASH statistics on binned data; the reduced χ^2 values are also shown to indicate the quality of the fit. In order to justify the significance of CASH statistics,

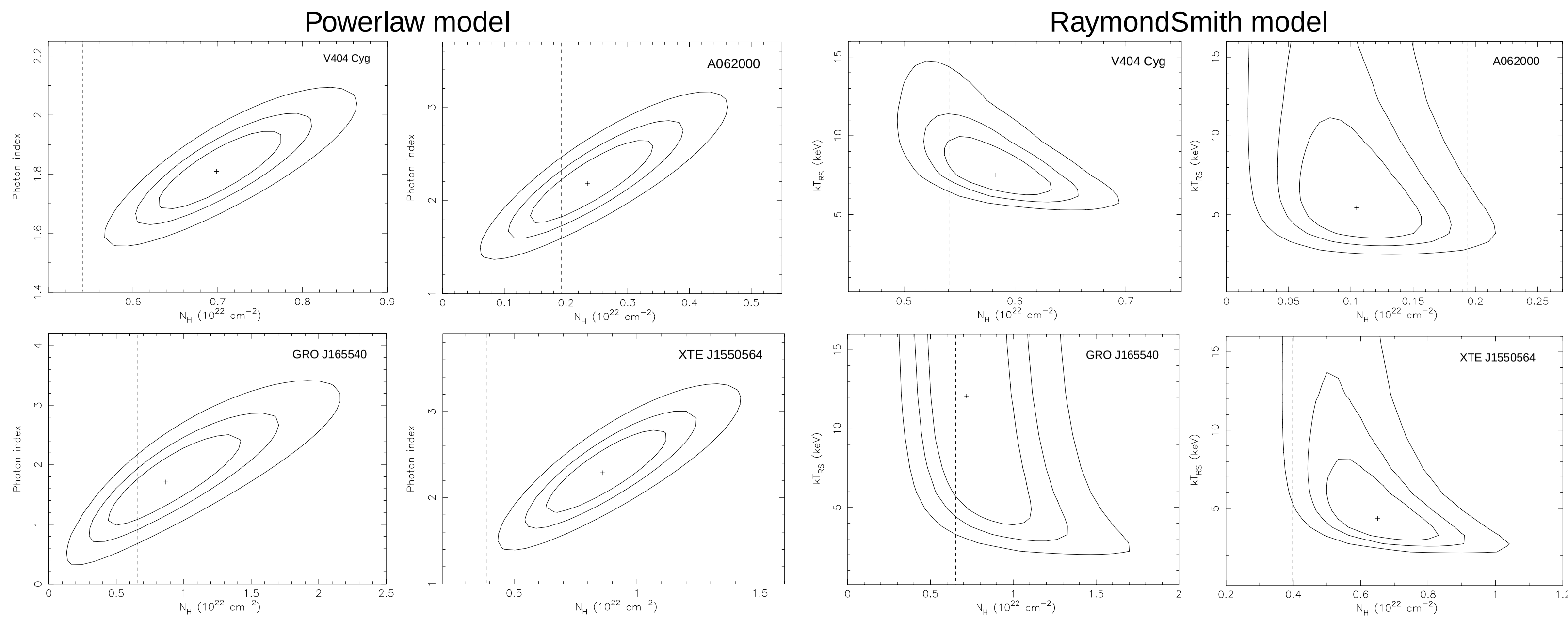

FIG. 2.—*Left*: Contour plot for the column density ($N_{\rm H}$) and photon index (α) derived from the *Chandra* spectrum of V404 Cyg, A0620−00, GRO J1655−40, and XTE J1550−564. The cross in the center marks the best-fit parameters and the contours encompass the 68%, 90%, and 99% confidence levels. Vertical dashed lines show the optically determined $N_{\rm H}$. *Right*: Contour plot for the column density ($N_{\rm H}$) and Raymond-Smith temperature ($kT_{\rm RS}$) derived from the *Chandra* spectrum of V404 Cyg, A0620−00, GRO J1655−40, and XTE J1550−564. The cross in the center marks the best-fit parameters and the contours encompass the 68%, 90%, and 99% confidence levels. Except for V404 Cyg, all of the plots were derived using CASH statistics. Vertical dashed lines show the optically determined $N_{\rm H}$.

we performed Monte Carlo simulations to estimate the significance level of the fits; these results are also given in Table 2.

Both methods give very consistent results. We also ran the fits with unbinned data using CASH statistics, and the results were consistent. We employed the same four single-component models with interstellar absorption that we used for V404 Cyg; the best-fit parameters for the various spectral models are shown in Table 2. Among all the models, the power law gives the best fit ($\chi^2/\nu = 0.71$, $\alpha = 2.2 \pm 0.5$), while the blackbody gives the worst fit ($\chi^2/\nu = 1.58$); Monte Carlo simulations based on CASH statistics also show similar results. The confidence regions for the power-law fit are shown in Figure 2 (*left*), and those for the Raymond-Smith fit are shown in Figure 2 (*right*). The best-fit Raymond-Smith temperature is $kT = 5.5$ keV, and the 90% lower bound on the temperature is $kT > 3.5$ keV.

The values of $N_{\rm H}$ determined by the power-law and bremsstrahlung fits are consistent with the optical value, corresponding to $N_{\rm H} = (1.94 \pm 0.28) \times 10^{21}$ cm^{-2} (Wu et al. 1976, 1983; Predehl & Schmitt 1995). The value of $N_{\rm H}$ determined by the Raymond-Smith and blackbody models is lower than the optical value. This conclusion provides marginal evidence that neither the blackbody nor the Raymond-Smith models are correct descriptions of the source spectrum because X-ray fits tend to find $N_{\rm H}$ higher than (or consistent with) the optically determined value. As in the case of V404 Cyg, we reran the fits with $N_{\rm H}$ fixed at the optically determined value. The results of these fits are also shown in Table 2. The derived parameters are consistent (within 1 σ) with the results obtained by varying $N_{\rm H}$, except for the case of the blackbody model. The best-fit temperature for the Raymond-Smith model is 4.1 keV, and the 90% lower bound is more than 2.8 keV.

Previously, the best measurement of the X-ray spectrum of A0620−00 was that taken by *ROSAT* (Narayan et al. 1997a), which gave $\alpha = 3.5 \pm 0.7$ with $N_{\rm H}$ fixed to the optical value. This led to the speculation that the quiescent X-ray spectra of BHXNs with orbital periods $\lesssim 1$ day might be softer than the spectra of longer period systems. However, this result was based on only 39 ± 8 detected source photons in the presence of a significant background. The present result is much more robust because it is based on more than 3 times as many counts, a negligible background, and a much wider energy band. It is important to note that A0620−00 was also a factor of $\sim$2 fainter in this *Chandra* observation than it was during the previous *ROSAT* observation. The best-fitting power-law model indicates a 0.4–2.4 keV emitted flux of 1.9×10^{-14} ergs cm^{-2} s^{-1}, corresponding to a luminosity of 2.1×10^{30} ergs s^{-1}, which is a factor of 2 below the *ROSAT* value (see Table 1).

4.3. *GRO J1655−40*

The spectrum of GRO J1655−40 was analyzed using the same methods discussed above for A0620−00. The energy spectrum was grouped into spectral bins containing at least 5 counts and fitted using χ^2 and CASH statistics. Unbinned data was also fitted using CASH statistics, and the results were consistent. All simple models give acceptable fits. While the blackbody model gives the poorest fits, it cannot be rejected on the basis of χ^2/ν and Monte Carlo simulations. However, the $N_{\rm H}$ for the blackbody model is slightly lower (1.5 σ) than the optical value of $(6.66 \pm 0.57) \times 10^{21}$ cm^{-2} (Predehl & Schmitt 1995; Hynes et al. 1998), while the other three models indicate values of $N_{\rm H}$ consistent with the optically derived value. The relatively low value of $N_{\rm H}$ suggests that the blackbody model may not be a true representation of the source spectrum.

The best-fit temperature for the Raymond-Smith model is $kT = 12.24$ keV, and the 90% lower limit on the temperature is $kT > 3.63$ keV. If we fix $N_{\rm H}$ to the optical value, these values are raised to $kT = 17.15$ keV and $kT > 5.8$ keV.

As above, we list the best-fit parameters in Table 2 and show a plot of the confidence regions for power-law and Raymond-Smith fits in Figure 2 (*left and right*). It is important to note that these observations show GRO J1655−40 to be a factor of $\sim$10 fainter than previous quiescent observations (see Table 1). The observed 0.4–2.4 keV emitted flux for the best-fitting power-law model is 1.5×10^{-14} ergs cm^{-2} s^{-1}; the observed 0.3–7.0 keV luminosity is 2.4×10^{31} ergs s^{-1}. The large decrease in flux and luminosity indicate that the previous *ASCA* observations may not have been taken during the true quiescent state because the observations occurred between two outbursts.

4.4. *XTE J1550−564*

We combined the two spectra of XTE J1550−564 as shown in Tomsick et al. (2001), grouped the resulting data into bins containing at least 10 counts each, and fitted the data to models using χ^2 and CASH statistics. The results of the spectral fits are shown in Table 2, and the corresponding parameter confidence regions are shown in Figure 2. All four models yield statistically acceptable fits, and we see no straightforward way to select one model over the others. With the exception of the blackbody model, all of the models indicate that $N_{\rm H}$ is somewhat higher than that determined optically (Sánchez-Fernández et al. 1999). However, as indicated above, this is only a weak argument against the blackbody model. Fits with $N_{\rm H}$ fixed to the optical value are also statistically acceptable and indicate harder (α lower, kT higher) spectra than the fits with $N_{\rm H}$ free.

The Raymond-Smith fits indicate a best-fit temperature of $kT = 4.38$ keV and a 90% lower limit to the temperature of $kT > 2.81$ keV. Fits with $N_{\rm H}$ fixed to the optical value raise these values to $kT = 10.31$ keV and $kT > 5.15$ keV. The results of the power-law fit are consistent with those found by Tomsick et al. (2001).

In order to determine if the quiescent X-ray emission of XTE J1550−564 has a flux consistent with a stellar corona, we calculated the unabsorbed X-ray flux ($F_{\rm X}$) and bolometric flux for XTE J1550−564 using the methods of Bildsten & Rutledge (2000). Based on our best-fit power-law result, the unabsorbed 0.4–2.4 keV flux of XTE J1550−564 is 2.98×10^{-13} ergs cm^{-2} s^{-1}. For the bolometric flux, we used $F_{\rm bol} = 10^{-0.4(V_q + 11.51 + {\rm BC} - A_V)}$ ergs cm^{-2} s^{-1} (Bildsten & Rutledge 2000), where BC is the bolometric correction for spectral type, V_q is the quiescent magnitude, and A_V is the reddening. We adopted a V_q of 22 ± 0.2 and a spectral type of K3 III from recent Very Large Telescope (VLT) observations (Orosz et al. 2002), which indicates BC $= -0.8$. We computed $F_{\rm bol}$ using the A_V determined from optical observations ($A_V = 2.17$; Sánchez-Fernández et al. 1999) and found $F_{\rm bol} = 5.1 \times 10^{-13}$ ergs cm^{-2} s^{-1}. We also determined $F_{\rm bol}$ using the A_V estimated from our X-ray spectral fitting. For a power-law model, $N_{\rm H} = 8.73 \times 10^{21}$ cm^{-2} implies that $A_V = 4.88$ (Predehl & Schmitt 1995), implying $F_{bol} = 6.1 \times 10^{-12}$ ergs cm^{-2} s^{-1}. These values of F_{bol} are discussed in § 6.

5. TIME-RESOLVED SPECTRUM OF V404 Cyg

The background-subtracted light curve of V404 Cyg during our observations is shown in Figure 3. The light curve shows a factor of ~2 variability in a few kiloseconds. We do not find any significant peak in the power spectrum on timescales from 2.3 to 10,000 s, and the 3 σ upper limit on the semiamplitude is 39% (0.3–7 keV).

The marked variability led us to search for spectral changes at differing flux levels. The data was divided into seven segments based on the source intensity (see Fig. 3). The spectrum from each segment contains at least 100 counts. The results of fitting each spectrum with a power-law model are shown in Table 3. The best-fit column density varied between $(2.91–11.08) \times 10^{21}$ cm^{-2}, and the best-fit photon index α varied between 1.1 and 2.4. We found no correlation between either the column density or α and the flux. However, we do find a positive correlation between the absorption column density and the photon index (see Fig. 4) with a correlation coefficient of 0.93 (> 99%).

However, we suspect that this correlation is not intrinsic to the source, but is rather an artifact of the fitting process that links α and N_H. For example, we note that the slope of the correlation is nearly (within ~5%) the same as the slope of the major axis of the parameter confidence contours (Fig. 2 [*left*]). Also, we extracted and examined two spectra, one for count rates below 0.11 counts s^{-1} and the other for count rates above 0.18 counts s^{-1} (see Fig. 3), and found them to be identical. We conclude that the spectral shape does not vary with intensity.

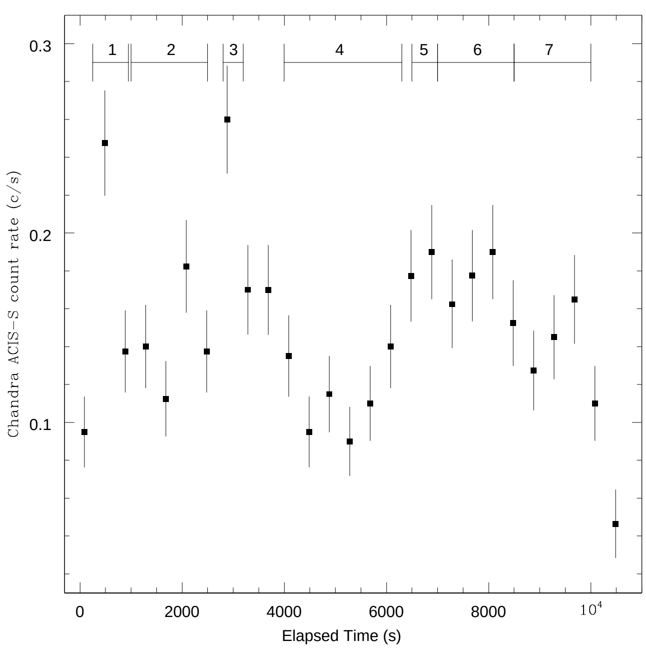

FIG. 3.—*Chandra* ACIS-S 10 ks light curve of V404 Cyg in the 0.3–7.0 keV band. The time resolution is 500 s. Also shown are the seven time intervals used for time-resolved spectral analysis.

TABLE 3

TIME-RESOLVED SPECTRAL PARAMETERS

Data Segment	N_H (10^{21} cm^{-2})	α	χ^2_ν/dof	Luminosity[a] (10^{33} ergs s^{-1})
1..............	10.21 ± 2.28	2.41 ± 0.41	1.21/11	8.07
2..............	5.08 ± 1.19	1.57 ± 0.26	0.88/16	2.81
3..............	6.14 ± 1.97	1.72 ± 0.40	0.41/7	4.83
4..............	6.47 ± 1.09	1.60 ± 0.20	0.85/28	2.81
5..............	2.91 ± 1.29	1.14 ± 0.40	1.17/6	4.26
6..............	5.86 ± 1.18	1.56 ± 0.24	0.85/21	3.82
7..............	11.08 ± 2.15	2.22 ± 0.31	1.11/17	5.32

[a] Luminosity in 0.3–7 keV, assuming a distance of 3.5 kpc.

6. DISCUSSION

We analyzed the *Chandra* ACIS-S X-ray spectra of four BHXNs in quiescence by fitting the spectra to simple one-component models (power-law, thermal Bremsstrahlung, Raymond-Smith, and blackbody) including interstellar absorption. While the statistics afforded by the *Chandra* data surpass that previously available, they are still inadequate to rule out any of these simple models, except for the blackbody model in the case of V404 Cyg. There is some weak additional evidence against a few other models: For A0620−00, the Raymond-Smith and blackbody models imply unlikely values of N_H that are lower than the optically determined values. The same is true for GRO J1655−40 and XTE J1550−564 in the case of the blackbody model. On the other hand, the thermal bremsstrahlung model provides a good fit to the data in all cases; however, the physical interpretation of this model is unclear (see Christian & Swank 1997). The model that does fit well in all cases and that has a straightforward physical interpretation is the power-law model with a photon index of ~2. This slope is consistent with the spectra expected for an ADAF.

Bildsten & Rutledge (2000) suggest that much of the X-ray flux observed from quiescent BHXNs may be produced by a rotationally enhanced stellar corona in the secondary star, as seen in tidally locked binaries such as the RS CVn systems. Lasota (2000) has criticized this view, suggesting

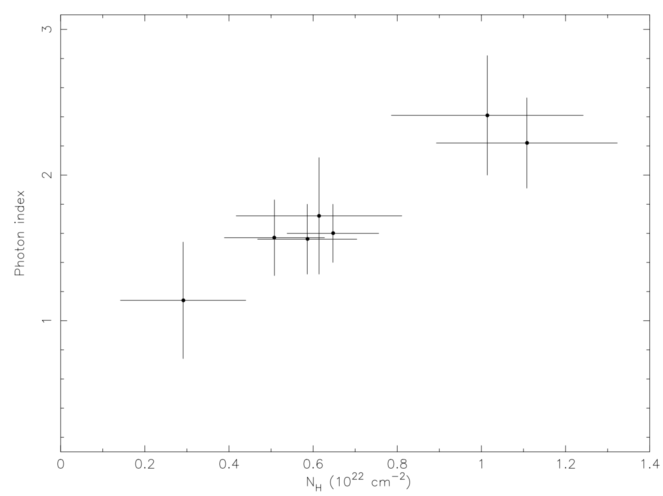

FIG. 4.—Plot of power-law photon index (α) against absorption column density (N_H). A positive correlation can be seen.

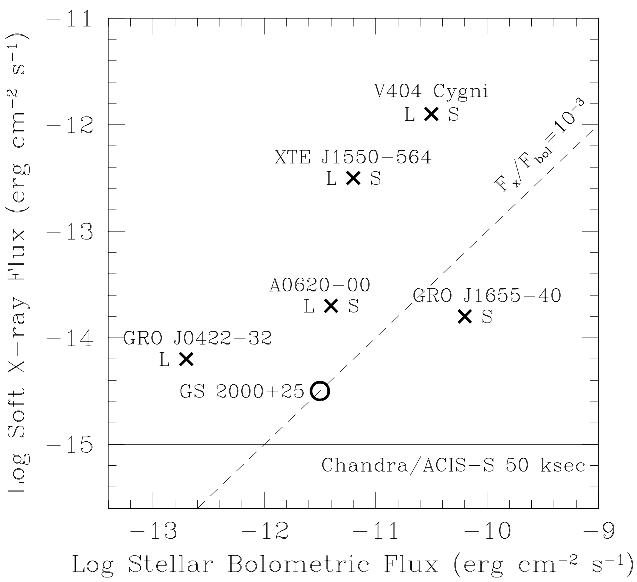

FIG. 5.—Quiescent X-ray and bolometric fluxes of BHXNs, after Bildsten & Rutledge (2000). X-ray fluxes are as reported herein or from G01, but in all cases converted to 0.4–2.4 keV emitted fluxes (note that Fig. 2 of Narayan et al. 2001 plotted a 0.5–10.0 keV flux for V404 Cyg, but agrees with this plot in all other respects). In cases in which the spectrum cannot be determined, we have assumed $\alpha = 2$. Bolometric fluxes are from Bildsten & Rutledge (2000) or as reported herein. An "X" indicates that the X-ray flux is unlikely to be due to a stellar corona, an "L" indicates that it is the X-ray luminosity that argues against this coronal hypothesis, and an "S" indicates that it is the spectrum. Based on the data herein, in only one (GS 2000+25) of the six BHXNs studied could the corona of the secondary produce a significant part of the detected X-ray flux.

instead that the physically smaller secondaries of CVs provide a better analog, and that in this case, the expected coronal emission is far below that seen in quiescent BHXNs.

The coronal hypothesis of Bildsten & Rutledge (2000) makes two clear, testable predictions: first, that $L_X < 10^{-3} L_{bol}$, and second, that the spectrum of a quiescent BHXN should be similar to that of a stellar corona, i.e., well represented by a Raymond-Smith model with $kT < 1.4$ keV (Dempsey et al. 1993). The luminosity and spectral evidence available for five of the six BHXNs observed by *Chandra* rule strongly against these hypotheses, as detailed below. Note that we do not include in this discussion a seventh BHXN observed with *Chandra*, 4U 1543−47 (see G01), because it contains a fully radiative secondary (Orosz et al. 1998) and is not expected to possess an X-ray corona. Consequently, this system is irrelevant to the present discussion.

Figure 5, which is adapted from Bildsten & Rutledge (2000), compares the quiescent fluxes of BHXNs with the predictions of the coronal model. The quiescent flux of GRO J0422+32 exceeds the maximum prediction of the coronal model by a factor of ∼60, and V404 Cyg exceeds this limit by a factor of ∼40. XTE J1550−564 exceeds the coronal limit by a factor of ∼50 for the highest L_{bol}, or ∼400 for the lowest L_{bol} computed in § 4.4. However, the luminosity of XTE J1550−564 should be treated with caution because a minioutburst occurred 120 days after this observation (see Tomsick et al. 2001). This situation is very similar to the case of the *ASCA* observation of GRO J1655−40 made between two outbursts, which gave a high value of the luminosity (see § 4.3). Finally, A0620−00 is a factor of ∼5 above the coronal prediction, which may be a significant discrepancy since the prediction corresponds to the maximum likely level of coronal emission.

Turning to the spectral evidence, we find herein that the X-ray spectra of V404 Cyg, A0620−00, GRO J1655−40, and XTE J1550−564 are harder (equivalently hotter) than typical spectra of stellar coronae. The average temperature for these sources as determined from the N_H free fits to Raymond-Smith models is 7.4 keV, and 10.1 keV for the N_H fixed fits. The average of the 90% lower limits to the temperatures is more than 4 keV (or more than 5.24 keV from the N_H fixed fits). Coronal sources are often fitted by Raymond-Smith models with two separate temperature components. The average of the higher of these temperatures has a value of 1.4 keV (Dempsey et al. 1993). Thus, in the four systems for which the data are of sufficient quality to allow us to measure the X-ray spectrum, the temperature is ∼5–7 times higher than the highest temperature typically seen from stellar corona.

Thus, the combination of spectral and luminosity information argue against a coronal source for the quiescent luminosity in five out of the six cases for which the coronal mechanism is potentially relevant (i.e., excluding 4U 1543−47). Only in the case of GS 2000+25, in which we are unable to determine a spectrum due to the very low number of counts, is it possible that coronal emission from the secondary dominates the quiescent luminosity.

During strong flares, stellar coronae are occasionally seen at temperatures higher than the 1.4 keV average value quoted above. For example, a "superhot giant flare" from Algol was seen to have a peak temperature of 12.37 keV (Favata & Schmitt 1999). In this regard, it is important to note that both A0620−00 and GRO J1655−40 were observed with *Chandra* at *lower* luminosities than in previous quiescent observations. Therefore, it is unlikely that these two systems were in a flaring state during our observations.

Either the secondaries in BHXNs have coronae unlike those seen before, or the source of the quiescent luminosity is not coronal. This is not to say that these secondaries do not have X-ray emitting corona, but merely that the luminosity from such a corona is swamped by the accretion luminosity even during quiescence. An obvious point to note is the following. Emission from a stellar corona will contribute at some level to the quiescent X-ray luminosity. If in a few cases this level is significant, then the accretion luminosities of the black holes must be even lower than our estimates and the argument for event horizons is further strengthened.

It is worth noting that the five BHXNs for which coronal emission is ruled out cover the full range of orbital period and stellar bolometric flux. It therefore seems unlikely that there is some particular region of parameter space in which the coronal model applies. In comparison, the ADAF model is consistent with all the observations, covering the full parameter space (Narayan et al. 1996, 1997a, 2001; Lasota 2000).

Results of this paper further constrain the required ADAF model. Quataert & Narayan (1999) proposed that significant mass can be lost to an outflow/wind in ADAF models. They also predicted the spectral shape for ADAF models with and without winds for V404 Cyg. Our observations indicate that the power-law photon indices of V404 Cyg, A0620−00, GRO J1655−40, and XTE J1550−564 are consistent with $\alpha \sim 2$. Therefore, models in which Comptonization dominates are favored (Narayan et al. 1997a); strong-wind models become unlikely unless δ (the fraction of the turbulent energy that heats the electrons) is large enough (Quataert & Narayan 1999). ADAF models also predict line emission in X-ray spectra (e.g., Narayan & Raymond 1999). We set an upper limit on the equivalent width of any line feature between 6.4–7 keV for V404 Cyg, and it is much higher than the theoretical prediction, even for a model with winds. A larger collecting area instrument such as *XMM-Newton* is needed to study this kind of feature. Recent *RXTE* and *Chandra* observations of XTE J1550−564 also suggest that the ADAF model can explain the quiescent X-ray emission, although it does not explain all the behavior observed at other wavelengths (Tomsick et al. 2001). The similarity of the quiescent spectra of V404 Cyg, XTE J1550−564, GRO J1655−40, and A0620−00 found herein suggests that they may all be described by a similar ADAF model. Detailed broadband spectral modeling of these systems should be considered in order to further constrain the models.

The sources discussed in this paper have a wide range of luminosities. V404 Cyg is the brightest quiescent BHXN in our sample, with a 0.3–7 keV luminosity of $\sim 5 \times 10^{33}$ ergs s^{-1}. In our *Chandra* observations, the source was somewhat more luminous than in previous quiescent observations in which the luminosity was about 10^{33} ergs s^{-1} (see Table 1). Wagner et al. (1994) reported that V404 Cyg exhibited a decrease in intensity by a factor of 10 in less than 0.5 days, while our *Chandra* observations showed a factor of 2 variability in a few kiloseconds. Wagner et al. (1994) also found that there may have been a factor of ~ 2 variability on timescales of ~ 30 minutes in the highest intensity bins for the *ROSAT* observations. Thus, V404 Cyg in quiescence shows variability in X-rays on both short-term (a few kiloseconds) and long-term (years) timescales. Significant X-ray variability in quiescence was also seen in 4U 1630−47 (Parmar et al. 1997), A0620−00 (Asai et al. 1998; Menou et al. 1999; also Table 1), and GX 339−4 (Kong et al. 2000). V404 Cyg and GX 339−4 are similar in some respects: for example, their quiescent X-ray luminosities are comparable (Kong et al. 2000, 2002), and GX 339−4 has also been observed to undergo X-ray variability by a factor of 3 during its quiescent or "off" state (Kong et al. 2002). Thus, variability in the quiescent state is common, which suggests that BHXNs in quiescence are not totally turned off. We note that XTE J1550−564 also varied in luminosity by a factor of ~ 2 during the two *Chandra* observations in quiescence (Tomsick et al. 2001); only V404 Cyg and GX 339−4 have a quiescent luminosity higher than XTE J1550−564.

In Figure 6, we plot the Eddington-scaled luminosities (based on the best-fit power-law model) as a function of orbital period $P_{\rm orb}$; this is an update of the same plot from G01. For the mass of XTE J1550−564, we assumed $M = 10.6\ M_\odot$ (Orosz et al. 2002); the distance to XTE J1550−564 is estimated to be 2.5–6.3 kpc (e.g., Sánchez-Fernández et al. 1999; Orosz et al. 2002), and we have adopted an average distance of 4 kpc. We note that for the three long orbital period systems (V404 Cyg: 6.47 days; GRO J1655−40: 2.6 days; XTE J1550−564: 1.55 days), the quiescent luminosity is higher than for the other systems (Fig. 6). This implies that the accretion rate in these systems is higher than for the others, according to the ADAF model

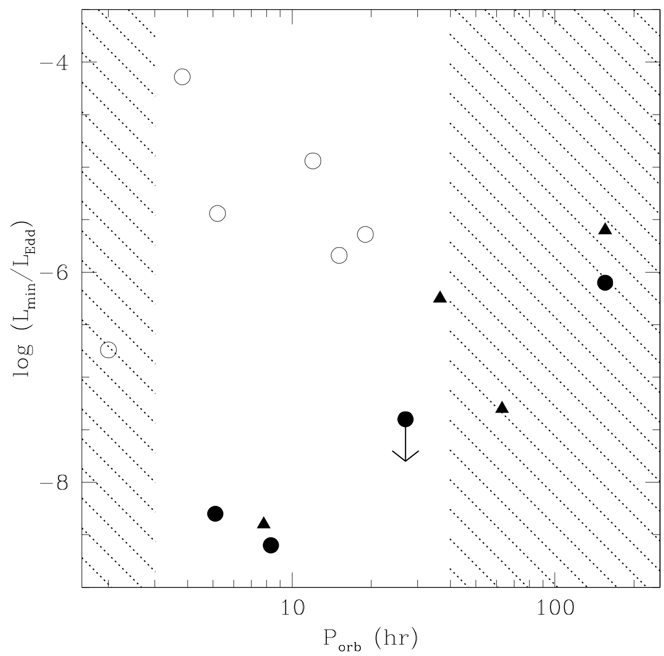

Fig. 6.—Quiescent luminosities of BHXNs (*filled circles and triangles*) and NSXNs (*open circles*) after G01. Data points in triangles are from the results of this work. Only the lowest quiescent detections (except for V404 Cyg, for which we show both the lowest detection and the luminosity derived here) or *Chandra* upper limits are shown. The nonhatched areas represent common orbital periods for BHXNs and NSXNs. The BHXNs shown are, from left to right, GRO J0422+32, A0620−00, GS 2000+25, 4U 1543−47, XTE J1550−564, GRO J1655−40, and V404 Cyg.

(Narayan et al. 1997a; Menou et al. 1999). It is not clear if there is a positive correlation between the luminosities and orbital periods (see Fig. 6); a larger sample of long orbital period systems is required to study this correlation.

In summary, we note that our results confirm the prediction of Lasota (2000), who previously pointed out that X-ray emission from a quiescent BHXN is unlikely to come from a stellar corona; instead he argues that the emission is due to an ADAF. Based on this model, Lasota (2000) predicted fluxes similar to those reported herein. Moreover, he pointed out that detection of GRO J0422+32 by *Chandra* would rule out the coronal model, and such a detection has been made (G01). However, our *Chandra* spectra are able to rule out only a few of the simple one-component spectral models we fitted to the data. With its larger collection area, observations with *XMM-Newton* should be able to do a significantly better job of constraining the source spectra. In addition, we note that V404 Cyg is variable on a few kiloseconds timescale, so simultaneous optical and X-ray observations may shed substantial light on the quiescent accretion processes in this source.

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traditionally studied in gas phase or in solid by conventional methods so that they are sure starting systems for Ihee's group to apply their new endeavor to unveil such processes as isomerization, bond breaking and forming in solution. In a long range, of course, they aim to decipher various enigmas of molecular biological processes, say, folding and unfolding of proteins to begin with.

The nominator believes that Ihee's graduate advisor, Ahmed Zewail, who is the Chemistry Nobel laureate in 1999 must be very proud of Ihee and his activity because Ahmed laid a road to ultrafast sciences dealing with gaseous systems, which was relayed to Ihee's enterprise to cultivate a vast virgin land of science (cf. Ihee's home page). Ihee is wisely utilizing synchrotron facilities in KEK, Japan, ERSF in Europe and APS in the US. Since the PF at KEK may be regarded as a heritage of Nishina who was eager in cooperative work of physics and chemistry, the nominator regards Ihee as one of the most eligible scientists.

Key references (up to 3 key publications*)

"Visualizing Solution-Phase Reaction Dynamics with Time-Resolved X-ray Liquidography", H. Ihee, *Acc. Chem. Res.*, **2009**, 42, 356-366.

"Tracking the structural dynamics of proteins in solution using time-resolved wide-angle X-ray scattering", M. Cammarata, M. Levantino, F. Schotte, P. A. Anfinrud, F. Ewald, J. Choi, A. Cupane, M. Wulff, H. Ihee, *Nature Methods*, **2008**, 5, 881-887.

"Filming the Birth of Molecules and Accompanying Solvent Rearrangement", J. H. Lee, M. Wulff, S. Bratos, J. Petersen, L. Guerin, J.-C. Leicknam, M. Cammarata, Q. Kong, J. Kim, K. B. Moller, H. Ihee, *J. Am. Chem. Soc.*, **2013**, 135, 3255-3261.

Nominator (name, affiliation, email, telephone and relation to the candidate)

Tadamasa Shida
Professor Emeritus, Kyoto University
e-mail: shida@kyoto.email.ne.jp
Tel: +81-(0)75-722-7841 (home)

Relation to the candidate: In September 2011 I made the acquaintance of Professor Ihee on the occasion of his lecture at Kobe University. He was invited to Japan by The Morino Foundation for Young Physical Chemists. As a committee member of that foundation I chaired Ihee's lecture to notice almost instantly that "This is genuine".

He introduced his idea to utilize ultrafast X-ray pulse to probe dynamical molecular structural changes by combining the pulse with separate UV-pulses to induce time-dependent photochemical processes in *liquid* phase. He maneuvered to extract desired information by subtraction of hampering diffraction signals due to irrelevant solvent molecules. Idea is simple, but performance requires the utmost consideration and skill. Above all, Ihee's approach has a potentiality of eventual thrust into clarification of molecular processes of life because the most events in living things occur in the aqueous solution in a wider sense.

I was once with Ihee's advisor, Ahmed Zewail, a Nobel laureate for chemistry in March 1987 when we had a bi-national seminar in Honolulu. I felt a strong aura emanating from him, a born Egyptian, who was on the way of climbing up in the academic world in the States. To me, Ihee's work seems to be a splendid extension of Ahmed's science from Gas to Liquid.

As for Nishina and myself, I was told that the room assigned to me to use from 1958 to 1964 was the very room that Nishina used. Here, I am talking about the original The Institute of Physical and Chemical Research (RIKEN) established in 1917, a part of the lot of The Institute is still being used by the present Nishina Foundation.

Thus, I have a special affection to the original RIKEN. Besides Nishina, the same room mentioned above once belonged also to the group of Professor Shoji Nishikawa, a worldly renowned X-ray crystallographer. His son is the late Professor Tetsuji Nishikawa, who was the former President of KEK where nowadays Ihee uses the PF machine occasionally.

Signature Takamasa Shida Date March 25, 2013

Nomination form for the 2014 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree of Ph.D., nationality, address, email and telephone)
Yu-Ao Chen Hefei National Laboratory for Physical Sciences at the Microscale University of Science and Technology of China (USTC) Jinzhai Road 96, Hefei, Anhui 230026, P. R. China Email: YuAoChen@ustc.edu.cn Phone: +86-186-56566677 Curriculum Vitae Since 2012 Professor for experimental physics (Youth Thousand Talent Plan), USTC 2009-2011 Project leader in the Quantum Optics and Quantum Many-body Systems group at Max-Planck Institute for Quantum Optics with Prof. Immanuel Bloch 2008-2009 Postdoctoral researcher in the QUANTUM group at the University of Mainz with Prof. Immanuel Bloch 2008 Scientific assistant in QUO group at the University of Heidelberg with Prof. Jian-Wei Pan 2004-2008 Ph.D. student at QUO group in Physikalisches Institut, Universität Heidelberg Ph.D., Received on 23rd January 2008 Supervisor: Prof. Jian-Wei Pan
Citation for the Award (within 30 words)
For his outstanding achievements in the fields of quantum manipulation of photons and atoms.
Description of the work

Yu-Ao Chen has done important fundamental research on experimental quantum information processing and quantum simulation via quantum manipulation of photons and atoms. In the past years, Yu-Ao Chen together with his colleagues has performed a number of significant experiments in the field. Since 2003, he has published 46 scientific papers on various topics in AMO physics, including 40 in high-impact journals (4 Nature, 6 Nature Physics, 5 Nature Photonics, 24 Phys. Rev. Lett. and 1 in PNAS. Among them, 17 out of 40 Yu-Ao was (equally contributed) first author or corresponding author. Till now, his refereed 46 publications have been cited more than 2200 times (ISI Web of Science) with h-index of 25. Many of his experiments were featured widely in scientific news services like: *Physics News Update, Physics-World, Scientific American, Science news online, the MIT Technology Research News and so on*. In recognition of "outstanding achievements in the fields of multi-photon entanglement, quantum communication, quantum computation and quantum simulation based on manipulation of photons and atoms", the European Physical Society recently awarded Yu-Ao the 2013 Fresnel Prize for fundamental aspects.

Yu-Ao received his Master degree from USTC in 2004. His early research was conducted with his colleagues setting-up a world first five-photon entanglement platform, culminating in a series of quantum optics papers on topics as test of quantum nonlocality, quantum teleportation, entanglement swapping. His 2004 paper on demonstration of five-photon entanglement and open-destination teleportation [Nature 430 54 (2004)] has been cited 312 times (ISI Web of Science) and later selected as Highlights of the year" by PhysicsWeb and "The Top Physics Story for 2004" by Physics News Update.

Later that year he joined the quantum optics group of Jian-Wei Pan, University of Heidelberg, with full support by Eliteförderung der Deutsche Telekom Stiftung, the most prestigious Ph.D. fellowship in Germany. Together with his colleagues, he has built up the new apparatus, which allowed complete a full series of experiments with storage ability, E.g. Memory-built-in quantum teleportation with photonic and atomic qubits [Nature Physics 4, 103 (2008), 87 cites, 1st author and corresponding author]; A millisecond quantum memory for scalable quantum networks [Nature Physics 5, 95 (2009), 85 cites, equally contributed 1st author and corresponding author]. In addition to the experiments he also worked on the conceptual formulation of a novel quantum repeater schema [Phys. Rev. Lett. 98, 240502 (2007), 86 cites], which is relaxing the severe phase stability problem in the original DLCZ schema. This theoretical work was the basis of the first demonstration of quantum repeater experiment [Nature 454, 1098 (2008), 124 cites, equally contributed 1st author and corresponding author], which is the first step towards realization of this novel protocol. Remarkably, one week before the experiment being published, the Nature editor distributed the featured press release to the media titled as "Quantum boost". Later this work was selected as "The best of 2008" by *Physics-World*. Due to his excellent performance he was awarded by Chinese government the "Chinese Government Award for Outstanding Self-financed Students Abroad" in 2006.

After Yu-Ao received his Ph.D. he joined the premier quantum simulation group of Prof. Immanuel Bloch in Mainz and moved together with the whole group to Max-Planck Institute for Quantum optics in Munich as project leader, where he was supervising a Masters student, a PhD student and a Postdoctoral researcher. By further developing the technique of optical superlattices, he is able to accomplish various experiments in quantum simulation. E.g. the experimental realization of strong effective magnetic fields [Phys. Rev. Lett. 107, 255301 (2011), 124 cites, corresponding author], allow one to access a parameter range of field strengths of several thousand Tesla, which are not accessible in real solids; Probing the relaxation towards equilibrium in an isolated strongly correlated 1D Bose gas [Nature Physics, 8 325 (2012), 97cites], can be seen as the first dynamical quantum simulator.

In the meantime, since 2009 Yu-Ao was advanced to a group leader position in USTC, where he supervised a world-level multi-photon entanglement experiment. The high scientific output of this experiment results in publications in highly renowned international journals (2 Nature, 1 Nature Physics, 3 Nature Photonics, 1 PNAS, 2 PRL). Most recently, his group has been able to manipulate eight-photon entanglement and succeeded to demonstrate eight-photon Schrödinger-cat state, which is largest photonic entanglement so far [Nature Photonics, 225 (2012)]. Further based the eight-photon entanglement, his group has demonstrated experimental topological error correction [Nature 482, 489 (2012), corresponding author]. Exploiting the high-brightness entanglement photon source to the field test experiment, together with his colleagues, he has succeeded to teleport independent qubits and to distribute entanglement over 100-km distance scale [Nature 488, 185 (2012), corresponding author]. In September 2011 he was awarded by the "Recruitment Program of Global Experts" as "Youth Thousand Talent Plan", establishing world-leading research programs on: further developing multi-photon entanglement; fundamental research on long-distance free-space quantum communication; space-based quantum memory; ultra-cold atoms in optical lattices based quantum many body physics. Meanwhile, since 2013, he was appointed as chief engineer for Quantum Secure Communication Backbone, which aiming a quantum secure communication network from Beijing to Shanghai over more than 2000 kilometers.

Key references (up to 3 key publications*)

1. Juan Yin, Ji-Gang Ren, He Lu, Yuan Cao, Hai-Lin Yong, Yu-Ping Wu, Chang Liu, Sheng-Kai Liao, Fei Zhou, Yan Jiang, Xin-Dong Cai, Ping Xu, Ge-Sheng Pan, Jian-Jun Jia, Yong-Mei Huang, Hao Yin, Jian-Yu Wang, **Yu-Ao Chen***, Cheng-Zhi Peng, Jian-Wei Pan
   Quantum teleportation and entanglement distribution over 100-kilometre free-space channels.
   Nature 488 185 (2012).
2. Xing-Can Yao, Tian-Xiong Wang, Hao-Ze Chen, Wei-Bo Gao, Austin G. Fowler, Robert Raussendorf, Zeng-Bing Chen, Nai-Le Liu, Chao-Yang Lu, You-Jin Deng, **Yu-Ao Chen*** &

Jian-Wei Pan

Experimental demonstration of topological error correction.

Nature 482, 489 (2012)

3. Zhen-Sheng Yuan, **Yu-Ao Chen*** (equally contributed first author), Bo Zhao, Shuai Chen, Joerg Schmiedmayer, and Jian-Wei Pan

   Experimental Demonstration of A BDCZ Quantum Repeater Node.

   Nature, 454, 1098 (2008).

* Corresponding author

*) Copy of one most significant publication should be attached.

Nominator (name, affiliation, email, telephone and relation to the candidate)

1. Yidong GU,

   Center for Space Utilization, CAS,

   Email: ydgu@aoe.ac.cn,

   Phone: +86-10-82178801

   Relation to the candidate: academic relation

2. Wenlong ZHAN,

   Headquarter CAS,

   Email: zhan@impcas.ac.cn,

   Phone: +86-10-68597612

   Relation to the candidate: academic relation

Signature Yidong GU Date March, 28, 2014

Signature Wenlong Zhan Date March, 28, 2014

Nomination form for the 2013 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree of Ph.D., nationality, address, email and telephone)

Name: Yoon-Ho Kim
Affiliation: Pohang University of Science and Technology (POSTECH), Korea
Citizenship: Korea
Address: Dept. of Physics, POSTECH, Pohang, 790-784, Korea
Email: yoonho72@gmail.com
Telephone: +82-10-5499-2093

Education:

2001	Ph.D. in Applied Physics, University of Maryland, Baltimore County (Maryland, USA)
1995	B.S. in Physics, Yeungnam University (Korea)

Academic Appointments:

03/2094 ~ Present	Assistant/Associate Professor of Physics, POSTECH, Korea
02/2012 ~ 02/2013	Visiting Professor,□Department of Electrical Engineering, Duke University, USA
03/2002 ~ 02/2004	Eugene P. Wigner Fellow, Oak Ridge National Laboratory, USA
06/2001 ~ 02/2002	Postdoctoral Research Associate, Oak Ridge National Laboratory, USA

Citation for the Award (within 30 words)

Experimental and theoretical researches on quantum decoherence and quantum measurement, leading to significant new findings on quantum-to-classical transition and decoherence suppression for entangled quantum systems.

Description of the work
One of the most remarkable properties of quantum physics is that the system of interest may be found in two or more quantum states simultaneously. Known as quantum superposition, it most starkly distinguishes quantum systems from classical ones, and multipartite quantum superposition is known as quantum entanglement, which is at the heart of the fast-evolving field of quantum information. To remain superposed or entangled, the quantum system must maintain quantum coherence. More often, however, quantum coherence is degraded or completely lost via unwanted interactions with the environment and such a process is known as decoherence. Since decoherence turns quantum systems into classical ones, the decoherence mechanisms and properties must be fully understood if we are to control quantum systems at will. In the cited works, decoherence mechanisms and their properties studied by using a single and an entangled quantum systems. Moreover, by utilizing the general quantum measurement theory, the concept of weak measurement is introduced and applied such that the effects of decoherence are suppressed. In particular, it was shown for the first time that it is possible to implement a reversing measurement so that decoherence applied to a single and entangled quantum system may be suppressed. This result has far reaching impact beyond the field of quantum photonics as the idea demonstrated may be applied to other quantum physical systems. Also, it was shown in theory and in experiment that, via multipartite interferometry, quantum to classical transition is non-monotonic. In fact, the work shows that the non-monotonic quantum-to-classical transition is a generic effect when multipartite coherence is involved. This work is expected to open up new methods of quantum control in the presence of decoherence.
Key references (up to 3 key publications*)
1. "Protecting Entanglement from Decoherence using Weak Measurement and Quantum Measurement Reversal" Y.-S. Kim, J.-C. Lee, O. Kwon, and **Y.-H. Kim**, <u>Nature Physics **8**, 117 (2012).</u> ⇒ Featured on the cover page, Nature Physics (Feb. 2012). ⇒ News & Views Article "Entanglement Preservation: The Sleeping Beauty approach" ⇒ Cited 46 times (Google scholar) **2. "Nonmonotonic quantum-to-classical transition in multiparticle interference"** Y.-S. Ra, M.C. Tichy, H.-T. Lim, O. Kwon, F. Mintert, A. Buchleitner, and **Y.-H. Kim**, <u>Proceedings of the National Academy of Sciences of the United States of America **110**, 1227 (2013).</u> ⇒ Cited 8 times (Google scholar) **3. "Reversing the weak quantum measurement for a photonic qubit"** Y.-S. Kim, Y.-W. Cho, Y.-S. Ra, and **Y.-H. Kim** <u>Optics Express **17**, 11978 (2009).</u> ⇒ Cited 50 times (Google scholar)

Nominator (name, affiliation, email, telephone and relation to the candidate)
Seunghwan Kim, President, Asia Pacific Center for Theoretical Physics, Pohang, Korea I have known him for a long time as a colleague of the Department of Physics, POSTECH, Pohang, Korea
Signature [signature] Date March 31. 2014

Nomination Form For the 2013 Nishina Asia Award

Candidate

Name: Yuanbo Zhang

Affiliation: Department of Physics, Fudan University, China

Curriculum: Ph.D. in Physics, Columbia University, 2006

Nationality: China

Address: Advanced Materials Building, Room 305, 2205 Songhu Road, Shanghai 200433, China

Phone: +86-18616137929

Email: zhyb@fudan.edu.cn, yuanbo.zhang@gmail.com

Professional Experience:

Professor of Physics, Fudan University, China, 2011-present

Postdoctoral Researcher, IBM Almaden Research Center, USA, 2010

Miller Research Fellow, University of California at Berkeley, 2006-2009

Citation for the Award

For his work understanding the electronic properties of graphene.

Description of the work

Dr. Yuanbo Zhang, while working in Prof. Philip Kim's group at Columbia University, is among the researchers who first discovered an unconventional quantum Hall effect in graphene, a mono-atomic layer of carbon. The effect implies that the charge carriers in graphene are massless Dirac fermions owning to graphene's special electronic structure. That work, published in Nature (Nature 438, 201 (2005)), is a widely used reference in the field of graphene research. Dr. Zhang also uses scanned probe and optical techniques to further elucidate graphene's electronic properties. His work has significantly advanced our understanding of graphene.

Key references

1. Y. Zhang, Y.-W. Tan, H. L. Stormer, P. Kim, "Experimental Observation of Quantum Hall Effect and Berry's Phase in Graphene" Nature 438, 201 (2005).

2. Y. Zhang, T.-T. Tang, C. Girit, Z. Hao, M. C. Martin, A. Zettl, M. F. Crommie, Y. R. Shen and F. Wang, "Direct Observation of a Widely Tunable Bandgap in Bilayer Graphene" Nature 459, 820 (2009).

3. Y. Zhang, V. W. Brar, C. Girit, A. Zettl and M. F. Crommie, "Origin of Spatial Charge Inhomogeneity in Graphene" Nature Physics 5, 722 - 726 (2009)

Nominator

Name: Ruibao Tao

Affiliation: Department of Physics, Fudan University, Shanghai 200433, China

Occupation: Professor in Physics, Member of Academy of Science, China

Email: **rbtao@fudan.edu.cn**

Telephone: +86-21-65642968

Relation to the candidate: Work in the same university.

Signature:

Date 18 February 2013

Yuanbo Zhang

Department of Physics, Fudan University
Advanced Materials Building, Room 305, 2205 Songhu Road, Shanghai 200433, China
Phone: +86-18616137929 *Email*: zhyb@fudan.edu.cn, yuanbo.zhang@gmail.com

Education

Ph.D. in Physics, Columbia University — June 2006

B.S. in Physics, Peking University, China — Fall 2000

Professional Experience

Professor of Physics, Fudan University, Shanghai, China — 2010-present

Miller Research Fellow, University of California at Berkeley — Sept. 2006-2009

Honors and Awards

Dongfang Scholarship Award, China — 2012
Thousand Young Talent Award, China — 2011
IUPAP Young Scientist Prize (C8), International Union of Pure and Applied Physics 2010
Miller Fellowship, University of California at Berkeley — 2006-09
Charles H. Townes Fellowship, Columbia University — 2005-06

Invited Presentations

Seminar, National Institute for Materials Science (NIMS), Tsukuba, Japan	Aug. 2012
5th workshop for Emergent Materials Research, Pohang, Korea	Jul. 2012
A3 Conference, Urumqi, China	Oct. 2011
CNMM International Workshop, Beijing	Sept. 2011
OCPA7 Conference, Taiwan	Aug. 2011
Semiconductor Physics Conference, Hohhot, China	Aug. 2011
The 11th Asia Pacific Physics Conference (APPC11), Shanghai	Nov. 2010
Dasan Conference on Graphene - New Science and Technology, Korea	Nov. 2010
30th International Conference on the Physics of Semiconductors, Seoul, Korea	Jul. 2010
International Conference on Superlattices, Nanostructures and Nanodevices, Beijing, China	Jul. 2010
Graphene Week, University of Maryland, College Park, USA	Apr. 2010
Seminar, University of Science and Technology, Hefei, China,	Nov. 2009
Seminar, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA	Aug. 2009
Colloquium, Department of Physics, National Taiwan University, Taipei	Mar. 2009

Seminar, Korea Advanced Institute of Science and Technology (KAIST)	Mar. 2009
Seminar, Samsung, Korea	Mar. 2009
Seminar, Sungkyunkwan University (SKKU), Korea	Mar. 2009
Colloquium, University of Virginia, Charlottesville, Virginia	Feb. 2009
Seminar, IBM Almaden Research Center, San Jose	Jan. 2009
Colloquium, University of Chicago, Chicago	Jan. 2009
Colloquium, University of California at Santa Barbara, Santa Barbara	Jan. 2009
APS March Meeting, Pittsburgh	Mar. 2009
Seminar, Georgia Institute of Technology, Atlanta	Nov. 2008
Seminar, Nanyang Technological University, Singapore	Nov. 2008
The 2008 Asian Conference on Nanoscience and Nanotechnology, Singapore	Nov. 2008
Seminar, Center for Nanoscale Science & Technology, Peking University	Oct. 2008
Colloquium, Department of Physics, Fudan University, Shanghai	Oct. 2008
Seminar, Department of Physics, Nanjing University, Nanjing	Oct. 2008
Seminar, Department of Physics, Renmin University, Beijing	Oct. 2008
Seminar, Department of Physics, Tsinghua University, Beijing	Oct. 2008
Seminar, Institute of Physics, Academia Sinica, Taipei	Oct. 2008
Seminar, Institute of Physics, Chinese Academy of Science, Beijing, China	Sept. 2008
International Conference on Nanoscience + Technology (ICN+T), Keystone	Jul. 2008
APS March Meeting, Denver	Mar. 2007
Free Electron Laser Workshop, Synchrotron Radiation Center, UW-Madison	Aug. 2006
Gordon Conference, Correlated Electron Systems, Mount Holyoke College	Jun. 2006
Seminar, IBM Almaden Research Center, San Jose	Jan. 2006

Publication List

1. Gang Mi, Likai Li, **Yuanbo Zhang** and Gengfeng Zheng "Sn-doped Bismuth Telluride Nanowires with High Conductivity" *Nanoscale* **4**, 6276 (2012).

2. J. Horng, C.-F. Chen, B. Geng, C. Girit, **Y. Zhang**, Z. Hao, H. A. Bechtel, M. Martin, A. Zettl1, M. F. Crommie, Y. R. Shen and F. Wang "Drude conductivity of Dirac fermions in graphene" *Phys. Rev. B* **83**, 165113 (2011).

3. A. Splendiani, L. Sun, **Y. Zhang**, T. Li, J. Kim, C.-Y. Chim, G. Galli and F. Wang "Emerging Photoluminescence in Monolayer MoS_2" *Nano Lett.* **10**, 1271–1275 (2010).

4. V. W. Brar (韦小宝), S. Wickenburg (魏烈钢), M. Panlasigui, C.-H. Park, T. O. Wehling, **Y. Zhang** (张远波), R. Decker, C. Girit, A. V. Balatsky, S. G. Louie, A. Zettl and M. F. Crommie "Observation of Carrier-Density-Dependent Many-Body Effects in Graphene via Tunneling Spectroscopy" *Phys. Rev. Lett.* **104**, 036805 (2010).

5. T.-T. Tang*, **Y. Zhang***, C.-H. Park, B. Geng, C. Girit, Z. Hao, M. C. Martin, A. Zettl, M. F. Crommie, S. G. Louie, Y. R. Shen and F. Wang "A Tunable Electron-Phonon Fano System in Gated Bilayer Graphene" *Nature Nanotechnology* **5**, 32 – 36 (2010).

6. **Y. Zhang***, T.-T. Tang*, C. Girit, Z. Hao, M. C. Martin, A. Zettl, M. F. Crommie, Y. R. Shen and F. Wang, "Direct Observation of a Widely Tunable Bandgap in Bilayer Graphene" *Nature* **459**, 820 (2009).

7. **Y. Zhang***, V. W. Brar*, M. F. Crommie, "Origin of Spatial Charge Inhomogeneity in Graphene" *Nature Physics* **5**, 722 - 726 (2009)

8. C. Girit, V. Bouchiat, O. Naaman, **Y. Zhang**, M. F. Crommie, A. Zettl, and I. Siddiqi, "Tunable Graphene dc Superconducting Quantum Interference Device" *Nano Lett.* **9**, 198 (2009).

9. **Y. Zhang**, V. W. Brar, F. Wang, C. Girit, Y. Yayon, M. Panlasigui, A. Zettl, M. F. Crommie, "Giant phonon-induced conductance in scanning tunneling spectroscopy of gate-tunable graphene" *Nature Physics* **4**, 627 (2008).

10. F. Wang, **Y. Zhang**, C. Tian, C. Girit, A. Zettl, M. F. Crommie, Y. R. Shen, "Gate-Variable Optical Transitions in Graphene" *Science* **320**, 206 (2008).

11. E. Stolyarova, D. Stolyarov, L. Liu, K. T. Rim, Y. Zhang, M. Han, M. Hybersten, P. Kim, G. Flynn "Scanning tunneling microscope studies of ultrathin graphitic (graphene) films on an insulating substrate under ambient conditions" *J. Phys. Chem. C* **112**, 6681-6688 (2008).

12. V. W. Brar, **Y. Zhang** et. al., "Scanning tunneling spectroscopy of inhomogeneous electronic structure in monolayer and bilayer graphene on SiC" *Appl. Phys. Lett.* **91**, 122102 (2007).

13. K. S. Novoselov, Z. Jiang, **Y. Zhang**, S. V. Morozov, H. L. Stormer, U. Zeitler, J. C. Maan, G. S. Boebinger, P. Kim, A. K. Geim, "Room-Temperature Quantum Hall Effect in Graphene" *Science* **315**, 1379 (2007). Brief Report.

14. Y.-W. Tan, **Y. Zhang**, K. Bolotin, Y. Zhao, S. Adam, E. H. Hwang, S. Das Sarma, H. L. Stormer, and P. Kim, "Measurement of Scattering Rate and Minimum Conductivity in Graphene" *Phys.. Rev. Lett.* **99**, 246803 (2007).

15. Z. Jiang, **Y. Zhang**, Y.-W. Tan, J. A. Jaszczak, H. L. Stormer, and P. Kim, "Graphene in extremely high magnetic fields" *Int. J. Mod. Phys. B* **21**, 1123 (2007). Review Article.

16. Z. Jiang, **Y. Zhang**, H. L. Stormer and, P. Kim, "Quantum Hall States near the Charge Neutral Dirac Point in Graphene" *Phys. Rev. Lett.* **99**, 106802 (2007).

17. Y.-W. Tan, **Y. Zhang**, H. L. Stormer, and P. Kim, "Temperature Dependent Electron Transport in Graphene" *Eur. Phys. J. Special Topics* **148**, 15 (2007).

18. M. Y. Han, B. Oezyilmaz, **Y. Zhang**, and P. Kim, "Energy Band Gap Engineering in Graphene Nanoribbons" *Phys. Rev. Lett.* **98**, 206805 (2007).

19. M. Han, B. Ozyilmaz, Y. Zhang, P. Jarillo-Herero, P. Kim "Electronic transport measurements in graphene nanoribbons" *PHYSICA STATUS SOLIDI B-BASIC SOLID STATE PHYSICS* **244**, 4134-4137 (2007). Review Article.

20. Z. Jiang, Y. Zhang, Y.-W. Tan, H. L. Stormer, and P. Kim, "Quantum Hall effect in graphene" *Solid State Comm.* 143, 14 (2007). Review Article.

21. J. Yan, **Y. Zhang**, P. Kim, A. Pinczuk, "Electric Field Effect Tuning of Electron-Phonon Coupling in Graphene" *Phys. Rev. Lett.* **98**, 166802 (2007).

22. M. S. Purewal, Y. Zhang, P. Kim. "Unusual transport properties in carbon based nanoscaled materials: nanotubes and graphene" *PHYSICA STATUS SOLIDI B-BASIC SOLID STATE PHYSICS* **243**, 3418-3422 (2006). Review Article.

23. **Y. Zhang**, Z. Jiang *et. al.*, "Landau Level Splitting in Graphene in High Magnetic Fields" *Phys. Rev. Lett.* **96**, 136806 (2006).

24. **Y. Zhang**, Y.-W. Tan, H. L. Stormer, P. Kim, "Experimental Observation of Quantum Hall Effect and Berry's Phase in Graphene" *Nature* **438**, 201 (2005).

25. **Y. Zhang**, J. Small, M. Amori, P. Kim, "Electric Field Modulation of Galvanomagnetic Properties of Mesoscopic Graphite" *Phys. Rev. Lett.* **94**, 176803 (2005).

26. **Y. Zhang**, J. Small, W. Pontius, P. Kim, "Fabrication and Electric-field-dependent Transport Measurements of Mesoscopic Graphite Devices" *Appl. Phys. Lett.* **86**, 073104 (2005).

Nomination form for the 2013 Nishina Asia Award

Candidate (name, affiliation, curriculum vitae including the date of the degree Ph.D, nationality, address, email and telephone)
Name: Hawoong Jeong **Affiliation:** KAIST-Chair Professor / Head of Department, Department of Physics, KAIST (Korea Advanced Institute of Science and Technology) **Curriculum Vitae:** **Nationality :** Korean **Email:** hjeong@kaist.ac.kr **Telephone:** +82-42-350-2543 **Address:** Department of Physics, KAIST, Daejeon, 305-701, South Korea **Education :** Feb. 26 1998 Ph.D. in Physics at Seoul National University Feb. 26 1993 MS in Physics at Seoul National University Feb. 26 1991 BS in Physics at Seoul National University **Professional Career:** 2011/5~present : KAIST Chair Professor & Head of Physics Department, KAIST 2001/9~2011/4 : Assistant/Associate/Professor at KAIST 1998/8~2001/8 : Post-Doc/Assistant Research Professor at Univ. of Notre Dame (USA) 1998/3~1998/7 : Post-Doc at Center for Theoretical Physics, SNU **Selected Publications:** 1. "Fundamental structural constraint of random scale-free networks" Phys. Rev. Lett. (2012) 2. "Googling social interactions: Web search engine based social network construction", PLoS ONE (2010) 3. "Dynamics and directionality in complex networks" Phys. Rev. Lett. (2009) 4. "Scaling laws between population and facility densities" PNAS (2009) 5. "Price of anarchy in transportation networks: Efficiency and optimality control" Phys. Rev. Lett. (2008) 6. "Metabolite essentiality elucidates robustness of E. coli metabolism" PNAS (2007) 7. "Universality class of fiber bundle model on complex networks", Phys. Rev. Lett. (2005) 8. "Role of the cytoskeleton in signaling networks", J. of Cell Science (2004) 9. "Subnetwork hierarchies of biochemical pathways", Bioinformatics (2003) 10. "Classification of scale-free networks", PNAS (2002) 11. "Modeling the Internet's large-scale topology", PNAS (2002) 12. "Comparable system-level organization of Archaea and Eukaryotes", Nature Genetics (2001) 13. "Lethality and centrality in protein networks", Nature (2001) 14. "The large-scale organization of metabolic networks", Nature (2000) 15. "Error and attack tolerance of complex networks", Nature (2000) 16. "The diameter of the World Wide Web", Nature (1999)

Citation for the Award (within 30 words)
Innovative scientist, who plays a major role in the opening and developing the entire new field of statistical physics, "network science" which is now considered as new way of understanding of complex system.
Description of the work
Prof. Jeong has played major role in the current revolution in new field of interdisciplinary science, "Network Science", whose work has been cited over 11,000 times from diverse fields. His activities have an invaluable impact, well beyond the boundaries of physics, concerning as well technological and biological system. Prof. Jeong's early papers on complex networks are now part of the canon of the field. Indeed, it was his 1999 paper in Nature that first described the emergence of the power law degree distribution in the World Wide Web, and this led to the introduction of the concept of scale-free networks, a true paradigm shift in the field. Since Prof. Jeong collected and analyzed the data that made this study possible, his role was the key in this discovery. One year later, in another Nature article (cover story), he contributed to the introduction of the error and attack tolerance concept. This was the first indication that the scale-free nature of real networks has an important impact on their ability to resist breakdown and failure. That idea in itself has developed into a major direction of inquiry within physics, computer science, and biology – the robustness of complex systems to node failure is now a much-explored topic. Prof. Jeong was first author of two papers, published in Nature in 2000 and 2001, that presented the first evidence that the scale-free state is not just a property of humanly-devised networks, but is also found in networks that took four billion years to emerge: those within living cells. His discovery that both metabolic and protein interaction networks are scale-free constituted the genesis of the new subfield of systems and network biology. In particular, his observation that hub status correlates with how essential a protein is has been hugely influential, and his paper on this topic was the first to alert biologists to the importance of network research. Also his 2000 Nature paper was called by a leading biologist an "essential reading for everyone engaged in metabolic network reconstruction" and has acquired almost two thousand citations. If Prof. Jeong had published no other work beyond that just described, he would still be a legend in this field. Since returning to Korea, however, he has initiated new research and continues to have a strong impact. He has been able to capitalize on his knowledge on networks to be a leader in the field by proposing new and important work in the area of biology, information network, socio/econo-physics, and statistical physics. The output of his research activity is phenomenal as witnessed by the number of papers and the high impact journal where he published such as PNAS and PRL. Of his recent work, "Subnetwork hierarchies of biochemical pathways" in Bioinformatics was highly cited and "Role of cytoskeleton in signaling networks" was selected as cover article in J. of Cell Science. Also he did not only theoretical calculation, but also collaboration with wet-biologist, to prove his idea with real bio-system, E. coli, in his 2007 PNAS paper. Besides bio-system, he works on socio/econo-physics

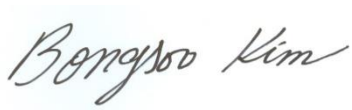
complex problems, such as grouping the stock market with eigen-vector based algorithm, and analyzing online social network services, like twitter and facebook. His work is highly appreciated from non-scientific field as well, for example, his 2008 PRL paper, “Price of Anarchy in transportation networks” was introduced in “The Economist” magazine as noticeable sci-tech paper. Of course, he studies traditional statistical physics problems as well, such as phase transition and synchronization, which were published in PRL. As shown above, Prof. Jeong combines very high intellectual curiosity with a wide range of interdisciplinary interest and technical expertise, and he has proved his excellency with a series of papers that have opened new field of science. He is an international leader in one of the most active subfields of physics, “network science”, one that is poised to radically redefine our thinking about complex system.

Key references (up to 3 key publications)

1. H. Jeong et al, "The large-scale organization of metabolic networks", Nature **407** 651 (2000) [cited 1978 times]
2. H. Jeong et al, "Lethality and centrality in protein networks", Nature **411** 41 (2001) [cited 1717 times]
3. R. Albert, H. Jeong, A.-L. Barabasi, “Error and attack tolerance of complex networks”, Nature 406 378 (2000) [cited 2057 times] [Nature Cover Article]

Nominator (name, affiliation, email, telephone and relation to the candidate)

Name: Prof. Dr. Bongsoo Kim
Affiliation: Department of Physics, Changwon National University, Changwon, Korea
Email: bongsoo.bskim@gmail.com
Telephone: +82-(0)55-213-3426
Relation to the candidate: A colleague in Korean statistical physics community

Signature:  Date: March 26, 2013