

Lev G. Titarchuk

Lev Titarchuk is a world recognized expert in High Energy Astrophysics, the Radiative Transfer Theory, in Data Analysis and interpretation of X-ray observations of NS and BHC systems. He participated in many approved CGRO, RXTE Guest Investigation Program and NASA APRA Program. In the eight years he with his collaborators has published more than 30 papers in the referred journals.

EDUCATION: Dr.of Sc.(Astrophysics) Leningrad State University, Leningrad (St. Petersburg), USSR June 1989. Prof. Rashid Sunyaev was a consultant
Ph.D. (Astrophysics) Space Research Institute (IKI), Moscow, June 1972. Prof. Vladimir Kurt was an advisor. M.S. (Mathematics) Moscow State University, July 1969.

DISSERTATION AND TITLE of DOCTOR of SCIENCE DEGREE:
Radiative Transfer Problems and Formation of the Spectra of X-Ray Sources.

PRESENT POSITION: Professor of University of Ferrara, Italy and Visiting Scientist in Goddard Space Flight Center, NASA

HONORS, and PROFESSIONAL SOCIETY MEMBERSHIP:
National Research Council-NASA Research Associateship Award, 1991 (Internationally recognized award).
NASA/ Summer Program Award, 2003, 2004 (Internationally recognized award).

Activity during the last six years

Teaching Activity

Lev Titarchuk gives two courses for undergraduate (master) students, Methods of Mathematical Physics and High Energy Astrophysics (Radiative Processes in Astrophysics).

The first course ``**Methods of Mathematical Physics**'' provides students a knowledge on Classification of partial differential equations., simplest physical problems leading to equations of hyperbolic type (equation of small transverse vibrations of a string, equations of longitudinal vibrations of rods and strings). Formulation of boundary and initial conditions for the physical problems related hyperbolic, parabolic equations. Methods of the solution of the boundary and initial value problem for the hyperbolic and parabolic equations. Methods of propagating waves and method of separation of variables. The maximum value principle for a solution of thermal conductivity and elliptical equations. Propagation of heat in an infinite and semi-infinite region. The Fourier's transformation method and the method of similarity in the theory of heat conduction. Problems reducible to Laplace's equation. Steady heat flow, potential flow in a fluid and potential of a stationary current and an electrostatic field. Solutions of boundary-value problems of Laplace's equation for the simplest regions by the method of separation of variables.

In the second course ``**High Energy Astrophysics**'' I present a study of fundamental problems of radiative transfer, basic theory of electromagnetic fields, radiation of moving charges, thermal bremsstrahlung emission and absorption, synchrotron radiation.

For graduate students, as a member of Doctorate Faculty I provide a course ``**X-ray spectral formation in compact objects (neutron star and black hole sources)**'' where I consider fundamental processes interaction of photons with plasma at rest and in motion, inverse Compton spectra for single scattering, energy transfer for repeated scatterings in a finite thermal medium, X-ray spectral formation for repeated scattering by nonrelativistic electrons, Unsaturated Comptonization spectra with soft photon input. Also I introduce students the main principles of formation of power spectra of X-ray radiation based on the theory of quasi-periodic oscillations of compact plasma regions (Compton cloud) surrounding neutron star and black holes.

Lev Titarchuk is an adviser of four graduate students, Chiara Ceccobello Caterina Lombardi, Simone Giacche, and Tais Maiolino.

Chiara Ceccobello presented and defended her thesis on X-ray spectral formation in NS sources in a presence of strong magnetic field in March of 2012. She published three papers in Astronomy & Astrophysics on the results of her thesis.

Caterina Lombardi is a graduate student of second year and she studies X-ray spectral appearances of Cyg X-3 using BeppoSax data. She is going to present a paper on this study in one of the refereed Journals.

Simone Giacche defended his master thesis on Analysis of X-ray spectral variability and black hole mass determination of the NLS1 galaxy Mrk 766.

On the results of these study Simone with his coauthors published a paper in Astronomy & Astrophysics.

Tais Mailino make a comparative analysis of X-ray data of white dwarfs, neutron stars and black holes in order to find observational signatures, similarities and differences of these objects.

Lev Titarchuk is also an adjunct professor of international center of relativistic Astrophysics (ICRA) where he presents lectures for students on the formation of X-ray spectra in BHs and NSs.

Research Activity

The main topics of Lev Titarchuk's scientific activity include: Theoretical Astrophysics of neutron stars and black holes and their timing and spectral appearances and formation of hard X-ray and Gamma-ray spectra of radiation of these objects. Theory of the resonance spectral line formation and the annihilation line formation. Theory of Comptonization of radiation in stellar atmospheres, and accretion disk coronae. General Relativity. AGN models. Theory of oscillations. Radiative Transfer Theory. Analytical and numerical techniques for solving the related Radiative Transfer problems,

improvement of the radiative transfer computer codes. Mathematical kinetic theory. Nonlinear problems of Hydrodynamics and Magneto-hydrodynamics. Timing and Spectral signatures of Black Hole (BHs) sources vs neutron star sources. Correlation of the spectral index in X-ray spectra with quasi-periodic oscillation (QPO) frequencies and mass accretion rate in BHs and also a discovery of the index saturation with QPOs and mass accretion rate for quite a few numbers of BHs. Estimates of BH masses using the index-QPO frequency (mass accretion rate) correlation. A stability of the spectral index vs mass accretion rate in NS Atoll and Z-sources. A model of X-ray and Gamma spectral formation in Gamma Ray Burst (GRB) sources. Lev Titarchuk is also CoPI of ADP NASA and SUZAKU NASA grants Below the details of a scientific activity by Lev Titarchuk and a list of his publications in the referee journals for the period from 2008 to 2016 are presented.

Lev Titarchuk has published more than 100 papers in the refereed journals. The total citation index of these papers according to NASA Astrophysics Data is about 6000 citations. He also was invited to give talks in various meetings and conferences more than 50 times.

LIST OF PUBLICATIONS IN THE REFERRED JOURNALS (2008-2016)

1. 2008 L. Titarchuk & N. Shaposhnikov "On the Nature of the Variability Power Decay Towards Soft Spectral States in X-Ray Binaries: Case Study in Cyg X-1" ApJ, 678, 1230
2. 2008 R. Farinelli, L. Titarchuk, A. Paizis, & F. Frontera
"A new Comptonization model for low-magnetized accreting neutron stars in low mass X-ray binaries" ApJ, 680, 602
3. 2009 E. Montanari, L. Titarchuk & F. Frontera
"BeppoSAX Observations of the Power and Energy Spectral Evolution in the Black Hole Candidate XTE J1650-500" ApJ, 692, 1597
4. 2009 N. Shaposhnikov & L. Titarchuk "Determination of Black Hole Masses in Galactic Black Hole Binaries using Scaling of Spectral and Variability Characteristics" ApJ, 699, 453
5. 2009 R. Farinelli, A. Paizis, R. Landi, & L. Titarchuk
"The X-ray spectral evolution of Cyg X-2 in the framework of bulk Comptonization" A&A, 498, 509
6. 2009 N. Shaposhnikov, L. Titarchuk & P. Laurent "Discovery of Red-skewed K_{α} Iron Line in Cyg X-2 with Suzaku" ApJ, 699, 1223
7. 2009 L. Titarchuk, N. Shaposhnikov & P. Laurent "On the Nonrelativistic Origin of Red-skewed Iron Lines in Cataclysmic Variable, Neutron Star, and Black Hole Sources" ApJ, 700, 1831
8. 2009 L. Titarchuk & E. Seifina "Discovery of Photon Index Saturation in the Black Hole Binary GRS 1915+105" ApJ, 706, 1463
9. 2009 M. Cocchi, R. Farinelli, A. Paizis, & Titarchuk, L. "Wide band observations of the X-ray burster GS 1826-238" A&A, 509, A2

10. 2009 M. Gliozzi, S. Satyapal, M. Eracleous, L. Titarchuk & C.C.Cheung "A Chandra View of NGC 3621: A Bulgeless Galaxy Hosting an AGN in Its Early Phase?" *ApJ*, 700, 1759
11. 2010 P. Chardonnet, V. Chechetkin, & L. Titarchuk, "On the pair-instability supernovae and gamma-ray burst phenomenon", *Ap&SS*, 325, 153
12. 2010 C. Shrader, L. Titarchuk, & N. Shaposhnikov "New Evidence for a Black Hole in the Compact Binary Cygnus X-3" *ApJ*, 718, 488
13. 2010 L. Titarchuk & N. Shaposhnikov "Implication of the observable spectral cutoff energy evolution in XTE J1550-564" *ApJ*, 724, 586
14. 2010 E. Seifina, & L. Titarchuk "On the Nature of the Compact Object in SS 433: Observational Evidence of X-ray Photon Index Saturation" *ApJ*, 722, 586
15. 2011 R. Farinelli & L. Titarchuk "On the stability of the thermal Comptonization index in neutron star low-mass X-ray binaries in their different spectral states" *A&A*, 525, 102
16. 2011 P. Laurent & L. Titarchuk "Spectral Index as a Function of Mass Accretion Rate in Black Hole Sources" *ApJ*, 727, 34
17. 2011 M. Gliozzi, L. Titarchuk, S. Satyapal, D. Price & I. Jang "Testing a Scale-independent Method to Measure the Mass of Black Holes", *ApJ*, 735, 16
18. 2011 E. Seifina & L. Titarchuk "On the Constancy of the Photon Index of X-Ray Spectra of 4U 1728-34 through All Spectral States" *ApJ*, 738, 128
19. 2012 R. Farinelli, C. Ceccobello, P. Romano & L. Titarchuk "Numerical solution of the radiative transfer equation: X-ray spectral formation from cylindrical accretion onto a magnetized neutron star", *A&A*, 538, 67
20. 2012 E. Seifina & L. Titarchuk "GX 3+1: The Stability of Spectral Index as a Function of Mass Accretion Rate", *ApJ*, 747, 99
21. 2012 L. Titarchuk, R. Farinelli, F. Frontera, L. Amati "An Upscattering Spectral Formation Model for the Prompt Emission of Gamma-Ray Bursts"
22. 2013 E. Seifina, L. Titarchuk & F. Frontera "Stability of the Photon Indices in Z-source GX 340+0 for Spectral States", *ApJ*, 766, 63
23. 2013 L. Titarchuk, E. Seifina & F. Frontera "Spectral State Evolution of 4U 1820-30: The Stability of the Spectral Index of the Comptonization tail", *ApJ*, 767, 160
23. 2013 L. Titarchuk, E. Seifina & F. Frontera "Spectral State Evolution of 4U 1820-30: The Stability of the Spectral Index of the Comptonization tail", *ApJ*, 767, 160
24. 2014 S. Giacchè, R. Gilli, & Titarchuk, L. "Analysis of X-ray spectral variability and black hole mass determination of the NLS1 galaxy Mrk 766", *A&A*, 562, 44
25. 2014 C. Ceccobello, R. Farinelli & L. Titarchuk "Comptonization in ultra-strong magnetic fields: numerical solution to the radiative transfer problem", *A&A*, 562, 99
26. 2014 L. Titarchuk, E. Seifina & N. Shaposhnikov "Black Hole Mass Determination in the X-Ray Binary 4U 1630-47: Scaling of Spectral and Variability Characteristics", *ApJ*, 789, 57
27. 2014 L. Titarchuk, E. Seifina & C. Shrader "X-Ray Spectral and Timing Behavior of Scorpius X-1", *ApJ*, 789, 98
28. 2014 I. Jang, M. Gliozzi, C. Hughes, & L. Titarchuk "Constraining black hole masses in low-accreting active galactic nuclei using X-ray spectra" *MNRAS*, 443, 72

29. 2015 E. Seifina, L. Titarchuk, C. Shrader & N. Shaposhnikov `` BeppoSAX and RXTE Spectral Study of the Low-mass X-Ray Binary 4U 1705–44: Spectral Hardening during the Banana Branch” ApJ, 808, 142
30. 2016 L. Titarchuk & E. Seifina `` Scaling of the photon index vs. mass accretion rate correlation and estimate of black hole mass in M101 ULX-1” A&A 585, 94
31. 2016 F. Frontera, L. Amati, R. Farinelli, S. Dichiara, C. Guidorzi, R. Landi, L. Titarchuk `` Possible physical explanation of the intrinsic E_p -“intensity” correlation commonly used to “standardize”, International Journal of Modern Physics D, Volume 25, Issue 5, id. 1630014
32. 2016 E. Seifina, L. Titarchuk & N. Shaposhnikov ``X-Ray Spectra of the High-mass X-Ray Binary 4U 1700-37” ApJ, 821, 23

Publications with the highest citation index

1. 1980 Sunyaev, R. A. & Titarchuk, L. G. ``Comptonization of X-rays in plasma clouds - Typical radiation spectra” A&A, 86, 121 (citation index is 939)
2. 1994 Titarchuk, L. ApJ, 434, 570 `` Generalized Comptonization models and application to the recent high-energy observations” ApJ, 434, 570 (citation index is 564)

In total, Lev Titarchuk has 11 publications (papers) for which the citation index of each paper is higher than 100.

Publications on discovery of a new method of black hole mass determination

1. NASA Press Release, May 16 , 2007,
http://www.nasa.gov/centers/goddard/news/topstory/2007/blackhole_weight.html

NASA Scientists Pioneer Technique for "Weighing" Black Holes

05.09.07

Two astrophysicists at NASA’s Goddard Space Flight Center in Greenbelt, Md., Nikolai Shaposhnikov and Lev Titarchuk, have successfully tested a new method for determining the masses of black holes.

This elegant technique, which Titarchuk first suggested in 1998, shows that the black hole in a binary system known as Cygnus X-1 contains 8.7 times the mass of our sun, with a margin of error of only 0.8 solar mass.

Cygnus X-1 was the first compelling black hole candidate to emerge in the early 1970s. The system consists of a blue supergiant star and a massive but invisible companion. Optical observations of the star’s wobble have suggested that the invisible object is a black hole containing about 10 solar masses. "This agreement gives us a lot of confidence that our method works," says Shaposhnikov.

"Our method can determine a black hole's mass when alternative techniques fail," adds Titarchuk, who is also a research professor at George Mason University, Arlington, Va., also works at the Naval Research Laboratory, Washington. Shaposhnikov works for the Universities Space Research Association, a part of the Center for Research and Exploration in Space Science and Technology within NASA Goddard.

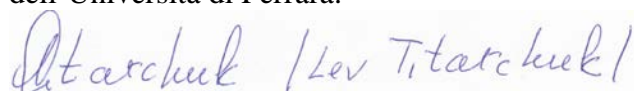
Working independently, Tod Strohmayer and Richard Mushotzky of Goddard and four colleagues used Titarchuk's technique to estimate that an ultra-luminous X-ray source in the small, nearby galaxy NGC 5408 harbors a black hole with a mass of about 2,000 suns.

"This is one of the best indications to date for an intermediate-mass black hole," says Strohmayer. This type of black hole fills in a huge gap between black holes such as Cygnus X-1, which come from collapsing massive stars and contain perhaps 5 to 20 solar masses, and monster black holes containing millions or even billions of solar masses, which lurk in the cores of large galaxies.

Titarchuk's method takes advantage of a relationship between a black hole and the surrounding disk of matter spiraling into it, called an accretion disk. Gas orbiting in these disks eventually falls into the black hole. When a black hole's accretion rate increases to a high level, material piles up near the black hole in a hot region that Titarchuk likens to a traffic jam. Titarchuk has shown that the distance from the black hole where this congestion occurs is on a direct scale with the mass of the black hole. The more massive the black hole, the farther this congestion occurs from the black hole, and the longer the orbital period.

In his model, hot gas piling up in the congestion region is linked to observations of X-ray intensity variations that repeat on a nearly but not perfectly periodic basis. These quasi-periodic oscillations (QPOs) are observed in many black hole systems. The QPOs are accompanied by simple, predictable changes in the system's spectrum as the surrounding gas heats and cools in response to the changing accretion rate.

Il sottoscritto acconsente, ai sensi del D. Lgs. 30/06/2003 n. 196, al trattamento dei propri dati personali e alla pubblicazione del presente curriculum vitae sul sito dell'Università di Ferrara.

 Titarchuk / Lev Titarchuk /