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Nikolai Voshchinnikov: From light scattering by spheroids to Large Interstellar Polarisation Survey

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ABSTRACT

This paper outlines the life and scientific legacy of Professor Nikolai Vasil'evich Voshchinnikov (1951–2017) who had many coauthors and friends among the *JQSRT* community.

1. Introduction

Nikolai Voshchinnikov was born in Leningrad, Soviet Union (now St.Petersburg, Russia) in 1951 to a family of a factory worker. He attended a special mathematical school and graduated from the Astronomy Division of the Mathematics Department of the Leningrad University in 1973. He worked at this University his whole professional life. In 1995 he became Professor of the Chair of Astrophysics. Around this time the Soviet Union dissolved, the iron curtain fell, and NV[1] started contacting and visiting foreign scientists; hence, his wide international collaborations began. His favorite places were Jena and Amsterdam, and more recently Heidelberg and Bonn.

In this paper I outline NV's scientific activities, which largely focused on *light scattering by small particles* (see Section 2) and *radiative transfer in dusty media* (see Section 3). The latter can be divided into two fields related to polarized scattered light and polarized transmitted light, both being considered in the astrophysical context. Generally, there was a gradual drift from the development of requisite light-scattering tools toward analyses of optical manifestations of cosmic dust based on these tools. While the characterization of non-sphericity of scatterers was the overarching goal, analyses of the observed polarization served as the main research tool.

Note that the scientific overview is accompanied by informal notes printed in smaller font.

2. Light scattering by small particles

The starting point of this research was a study of radiation pressure on non-spherical particles. Following this study, NV began his life-long work on light scattering by spheroids (see Section 2.1). Occasionally he considered other problems, such as different light-scattering approximations (Section 2.2), optical effects of particle shape and morphology (Section 2.3), and certain related issues (Section 2.4).

2.1. Light scattering by spheroids

Initiated in 1981, his work on light scattering from spheroids continued for over 35 years, mostly in collaboration with Victor Farafonov of the St.Petersburg University of Aerospace Instrumentation. Note that by the early 1980s, not too much work had been done on light scattering by spheroids (see the review by Onaka [1]). There was an approach developed in 1975 by Asano and Yamamoto [2] based on the separation of variables method (SVM)

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[1] Some colleagues called Nikolai so because his family name was very long and his name was too often met in Russia.

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Fig. 1. NV at the age of 50. Note that smoking was not yet as restricted in Russia as last years.

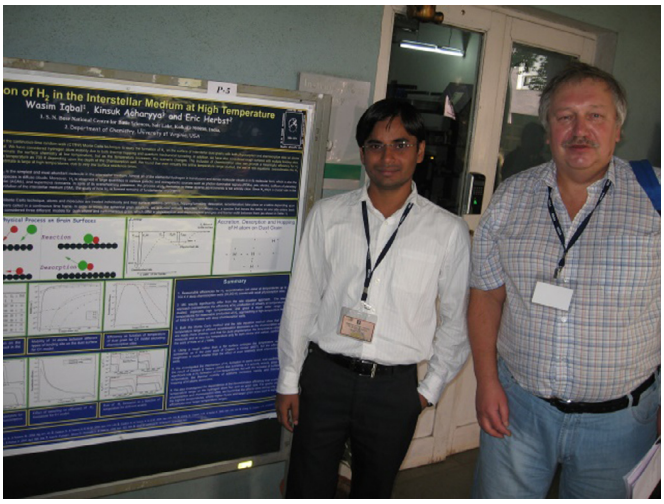

Fig. 2. At an astronomical conference in India in the 2010s.

with a spheroidal-function basis. The book [3] published in 1980 by Varadan and Varadan clearly demonstrated that the *T*-matrix method was a powerful approach, but was, however, impracticable in application to spheroids with aspect ratios greater than 5–10. In 1973, Purcell and Pennypacker had yet suggested the idea of the discrete dipole approximation [4]. So, in fact, the *exact* solutions of the Maxwell equations were mostly limited to spheres and infinite circular cylinders.

Voshchinnikov and Farafonov developed a new version of the SVM wherein the fields were divided into two parts having suitable properties, and appropriate scalar potentials were used for each part (for more details, see the work by Farafonov [5]). This approach is especially beneficial in application to spheroids with high eccentricities [7]. A serious problem was the absence of reliable computer subroutines to calculate the requisite spheroidal functions, in particular, those of complex argument. A new technique was developed and several known methods were adapted to address this problem [8,9]. The main outcome was a widely applied program that calculates the optical properties of homogeneous spheroids and an accompanying code for core-mantle spheroids with confocal layer boundaries, as well as extensive analyses of the optical properties of spheroids. A review of this research reported in many publications can be found in the NV's most cited paper [10] and his third most cited work [11]. The computer programs for spheroids and some other light-scattering codes developed by NV are available on the DOP website[2]. The last years featured serious efforts intended to develop a method to treat multi-layered spheroids lacking confocallity of the layer boundaries, the first step of which was reported by Farafonov and Voshchinnikov [12], but unfortunately this work remains unfinished.

It is amusing that in the years of perestroika, there was hope that the efficient computer program for spheroids could serve as a source of extra income, especially given the inadequate salaries of scientists in the Soviet Union. Unfortunately, only one buyer was found, a worker at the FujiFilm company, and he could only pay, and did pay, with their 35-mm film. [3] *Reselling so much film became an insurmountable problem). (Fig. 1)*

Fig. 3. NV with his wife and daughter in the 1990s.

2.2. Light scattering approximations

In the times when computers and computational methods were not as powerful as they are today, different approximations were very popular in the discipline of light scattering. NV made several studies in this field by considering the quasistatic approximation [13,14], the *S*-approximation [15], concentric multi-layered models of inhomogeneous particles [16], and the effective medium theory [17]. Some results can be found in his extensive review [18].

To realize how primitive the computers were during those times, it is worth noting that NV's work on the spheroidal code in 1985–1992 was done on a Model ES 1030 computer with just 500 Kb of

[2] http://www.astro.spbu.ru/DOP/6-SOFT/ours.html

[3] And a couple of big boxes arrived.