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## Reconstructing magnetic fields of spiral galaxies from radiopolarimetric observations

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<sup>1</sup>Of the Fokker-Planck equation.

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This thesis is dedicated to my loving Parents who have always been there with me at every moment throughout my whole life and their Guidance has made it possible for me to maintain the necessary focus to complete all the herculean tasks along this PhD journey. Thank You for making my childhood, teenage years, and adulthood so very special! Thank You for being so absolutely Happy for me and also to worry for me all these years. I do miss you very much!

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# About the Author

When I was around 3 years of age, my grandparents, who, prior to my birth, had settled in Brooklyn, New York, traveled to Amsterdam, bringing back beautiful wooden miniature Dutch sail ships. I remember dreaming to see these in a real life. They recall the *déjà vu* feeling of seeing much of their beloved St. Petersburgs public squares, canals, and bridges appear right before their very eyes in Amsterdam. And as soon as I was born, the Netherlands / St. Petersburg 'looking-glass' became part of the Dutch thread that has always been running through my life, but allow me to start from the very beginning...

Indeed, Tsar Peter the Great had invited Dutch architects to make his great vision of a new port city real; a bright 'window to Europe'. Supervised by the Tsar himself, construction of St. Petersburg began on 27 May 1703 on Zayachy<sup>1</sup> Ostrov. The first Russian atlas, 'Atlas of Cruys'<sup>2</sup>, was published in Amsterdam in 1703-1704.

In 1712, St. Petersburg became the capital of Russia and, with time, it blossomed into a great cultural center of art, classical music, literature, theater, ballet, and science. The Hermitage, Peterhof (Dutch for 'Peter's Court'), St. Isaac's Cathedral, the world-renowned Mariinsky Theater are among prime examples. In 1726, Peter the Great invited Professor Willem Jacob s Gravesande of Leiden University to set up the Academy of Sciences in St. Petersburg. Several years prior, the Tsar himself had traveled to the Netherlands where he lived and studied shipbuilding in Amsterdam and Zaandam. Tsar Peter's House, along with a monument, are to be found in Zaandam and a life-size statue of Peter the Great, in Rotterdam.

Two centuries later, this same city became a happy home for my paternal great-grandparents' family: a college mathematics pedagogue and his wife, a beautiful nurse with a Bachelor's degree, and their two young children, a son and a daughter - my grandmother who used to tell me so many fascinating stories about St. Petersburg. Stories about the birth of a marvel that began with the construction of a 'Petropavlovskaya Krepost', the citadel of St. Petersburg, named after the Apostles Peter and Paul, and designed to protect

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<sup>1</sup>Russian for 'hare' or 'rabbit'.

<sup>2</sup>Cornelius Cruys (1655 1727) was a Dutch Vice Admiral of the Imperial Russian Navy and the first commander of the Russian Baltic Fleet.



the entrance of the river Neva's delta from constant attacks by the Swedish flotilla ('Trubetskoy', one of the bastions of the citadel, had a wind-mill), buildings whose facades were composed of muses and mythological figures, and how the city's 273 islands were, one by one, linked by beautifully decorated bridges and draw bridges, that allowed tall ships to continue their journey... My grandma would also tell me about her brave journey through WWII, how the war began and how suddenly she lost her father, then younger brother, and finally her beautiful mother and became a 15 year old Jewish orphan surviving in a frozen city through two and a half years of unbearable hunger during Leningrad's Blockade, known as the Siege of Leningrad, by the Nazis. (Saint Petersburg had been renamed to Leningrad in 1924 and then rechristened in 1991.)

Thanks to the great aid of the Dutch Consulate in Russia, my parents and grandparents on both sides of the family, unbeknownst to each other at the time, were able to leave Russia and emigrate to the US. They eventually settled in Brooklyn, New York in the historic Coney<sup>3</sup> Island area.

It is in Coney Island that my parents met. (It's puzzling that my parents had always resided near each other: my maternal grandparents' apartment where my mother lived, was located in a building that was a former residence of Peter Carl Faberge (famous for the eponymous eggs) and my father's Architectural and Construction Engineering college, where he earned a Bachelor's degree, were both located on the same street.)

Thus, I was born in Brooklyn, 338 years following the founding of The New Netherland settlement of Breuckelen in 1646, named after Breukelen in the Netherlands. Many avenues and streets bear Dutch names (Amsterdam Avenue in NYC, New Utrecht Avenue in Brooklyn, etc.) and this also holds for most of New York State. Growing up speaking English and Russian at home - two languages greatly influenced by the Nederlandse Taal - many common Dutch words were actually spoken. Herring and smoked Gouda cheese were culinary favorites. Reproductions of several paintings by Rembrandt (namely, the 'Jewish Bride' and 'Prodigal Son') and that of Frans Hals ('Portrait of an Officer') adorned the walls of both my grandparents homes. Throughout my childhood, during winter vacations, my parents would take me to Aruba, the Dutch Caribbean.

When I graduated summa cum laude (4.4/4.0) from High School with a standard diploma and an additional International Baccalaureate (IB) diploma, the Director of the IB program of my High School presented me with a Certificate of Achievement for earning straight 'A' marks in all subjects, every six week grading period during all four years of study. I was the only student able to do so in my graduating class of 2002, though that year our class had the second highest number of graduates with IB diplomas in all of North America. My higher level subjects were Physics, Mathematics, and English literature. I was also selected as a member of the National Honor Society, Spanish National Honor Society, and Mathematics Honor Society.

I received a scholastic scholarship to attend Rensselaer Polytechnic Institute (RPI) co-founded in 1824 in New York by Stephen van Rensselaer III, a descendant of an important Dutch family. The results of my IB exams and additional Advanced Placement and Scholastic Aptitude Test II exams enabled me to start university at the second year of

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<sup>3</sup>Coney is derived from the Dutch word for 'rabbit' and also refers to 'hare'.

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study. There are many Dutch traditions at RPI, the ‘Dutchman’s Shoes’ football trophy, Dutch medieval graduation garments, as well as the scepter that the President of the University carries during important ceremonies. Following the first two years at RPI, I won the RPI-ETH scholarship to study Physics and Mathematics for two semesters at ETH, Zurich starting in Autumn 2004. The summer right before starting at ETH, Professor Ingrid Wilke most kindly worked with me at RPI and I was, thus, able to receive a research scholarship to work for three months as a research assistant in Professor Wilke’s Terahertz laboratory, where Dr. Ricardo Ascázubi was my kind mentor.

In 2005, ETH was the center of the Centennial Celebrations of Einstein’s *Annus Mirabilis*. It is during this occasion that many Nobel Prize Laureates, together with a Fields Medalist, most kindly autographed for me a large and beautiful poster-portrait of Einstein, resulting in an awesome signed document for future posterity to acknowledge, maybe in the next 100 years, that such a wonderful gathering of distinguished scientists had taken place at ETH. They were all very friendly, kind and even praised me for the idea.

Subsequently, I completed my fourth year at RPI, graduating in 2006 with a Master’s degree in Applied Mathematics, a Bachelor’s degree in Physics (*cum laude*), a Bachelor’s degree in Pure Mathematics (*cum laude*), and a minor degree in German language, which may be a record of special achievement at RPI in the sciences. Knowledge of the German language would help me to understand the Dutch language at a faster pace. I was also inducted into the Sigma Pi Sigma National Physics Honor Society.

Professor Jürg Fröhlich of the ETH most kindly advised me on the excellent tradition of statistical mechanics in the Netherlands and I matriculated to Utrecht University in the year of the 400th anniversary of Rembrandt’s birth. I received the Utrecht Excellence Scholarship and after two years of study earned a Master’s degree in Theoretical Physics in 2008 with a thesis in the subject of String Theory/Quantum Gravity under the supervision of Professor Jan Ambjørn. The Academic building, where the graduation ceremony took place, was the site where the Union of Utrecht was signed on 23 January 1579.

During a gap year, visiting my parents and grandparents, I became interested in turbulence and in cosmic magnetic fields. Hence, I matriculated to the University of Cambridge in 2009 and was a member of St. Catharines College. I entered Part III of the Mathematical Tripos during the 800<sup>th</sup> anniversary celebrations of the university and earned the degree of Master of Advanced Study.

Following this, in August 2010, I commenced my PhD research at Leiden University under the supervision of Dr. Marijke Haverkorn. The results of this research comprise this thesis. (Historically, many of the US Pilgrim Fathers lived in Leiden and worked at Leiden University. John Quincy Adams, the 6<sup>th</sup> President of the US (1825 - 1829), studied at Leiden University during his father’s<sup>4</sup> diplomatic mission to the the Netherlands.)

During my PhD, I attended conferences in the Netherlands, Germany (Bonn, Hamburg, Mainz, Munich - Ringberg Castle), Italy (Bologna), UK (Dublin, Newcastle upon Tyne) and also established an enduring close collaboration with Professor Anvar Shukurov and Dr. Andrew Fletcher, both of Newcastle University, UK. With the kind aid of Profes-

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<sup>4</sup>John Adams, 2<sup>nd</sup> President of the US (1797 - 1801).

sor Anvar, my impromptu presentation at the DFG Research Unit 1254 Summer School 2011 at Ringberg Castle to address Professor Uli Klein's request for a proof of Cowling's anti-dynamo theorem, helped secure this collaboration which proved absolutely essential and, thus, during the second and third year of my PhD, I was a visiting researcher at Newcastle University for a total of over 3 months.

At the time of writing, I have accepted a position at the Diagnostic Image Analysis Group, a division of the Department of Radiology and Nuclear Medicine of Radboud University Medical Center.

And in August of this year, 2015, I did see a most beautiful display of real size Dutch wooden sail ships that, like a beautiful mirage, all appeared in Amsterdam - an event that takes place only once in 5 years. And standing there, I remembered a little boy, het dappere snijdertje, who has been dreaming of such a magical day...

"All grown-ups were once children - although few of them remember it" wrote Antoine de Saint-Exupéry. Being a snijder in 17<sup>th</sup> century Leiden was a very important profession. Would you wonder with me, how, 400 years later, this Carl Shneider van Brooklyn fairs in the 21<sup>st</sup> century...