Biographical notes written for the Shaw Foundation (Autumn 2017)

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I was born on 30th September 1951 to Gwynneth Hallett, a maid in a small seaside boarding house in Kent. I never met my father. My mother changed her last name to match his in order to shield me from the prejudices of the time. Without independent means or family support, it was difficult for an unmarried mother to make a living and care for her child. We moved from one live-in job to another, ending up in Cornwall where my mother had been evacuated from London to escape the World War II bombing. In 1955 she took a job as house-keeper for George Symmons, a retired naval cook and country grocer who was 30 years her senior. George's first wife had died a few years previously, and, after passing his business to his oldest son, he had retired to a 400 year-old farm-worker's cottage in rural South-East Cornwall, supplementing his meagre naval pension by renting out caravans to holiday-makers. A year later, on my fifth birthday, George and my mother were married and I gained three step-brothers old enough to be my father, as well as assorted other Cornish family.

Learning to read with mother, circa 1955

A few days later I started school at Barra Head primary which, for most of the six years I spent there, had a single teacher and fifteen to twenty pupils, mostly farm children. My mother initially took me to school on her bicycle, but soon I was walking the two miles there and back, using the time to learn about the many birds, animal and plants inhabiting the hedgerows of narrow Cornish lanes. Saturdays were spent doing gardening and other chores at home, as well as cleaning caravans in the summer or painting and repairing them in winter. Sundays we would often drive to a local "beauty spot", but we never went away on holiday. Neither my mother nor my step-father were regular church-goers, but I did visit the local Methodist "sunday-school" for a few years. At school, I was soon far ahead of my class-mates and so spent my time reading and learning on my own. Struck by my precociousness, the teacher alerted Peter Portwood, the county's educational psychologist in far-away Truro. He took considerable interest in me and was responsible for getting me out of rural Cornwall into a much more academic environment.

Peter had been a pupil at Christ's Hospital, often called the blue-coat school because of its distinctive tudor uniform. CH was founded in 1552 in the City of London as a refuge for poor children, and although it is today located in the Sussex countryside, it remains a charitable institution dedicated to providing an academic education to children in social, financial or other need. Peter found a sponsor (another "Old Blue") to support my time at the school, and arranged for me to take the formidable examinations required for entry. Thus in 1962, just before my eleventh birthday, I found myself leaving home to start spending three twelve-week terms a year away from my family, which had just been extended by the birth of my half-brother John William Symmons.

In school uniform circa 1968

I attended CH (at the time, a school for boys only) from 1962 until 1968. I was a reserved schoolboy who did not make friends easily, particularly since the culture in my boarding house was hierarchical and disciplined, with a rigour which sometimes veered into bullying. My academic strengths were in languages, mathematics and physical sciences, and enjoyed choral and instrumental music, singing in the school choir and learning the violin. I was smaller than average and an indifferent although reasonably enthusiastic sportsman. Between terms I would take the train back to my family in Cornwall, but life there was difficult because my step-father's health was worsening (a life-long smoker, he developed chronic emphesyma) and he felt that my "fancy" education was spoiling me. This led to accusations that I wasn't pulling my weight, and to acrimonious arguments with my mother which left emotional scars on everyone, particularly my half-brother. After taking 'O' and 'A' levels, I sat the Oxbridge entrance examinations in late 1968 and won an Exhibition to study mathematics at Jesus College, Cambridge.

I left CH at the end of 1968 and so had a nine month gap before going up to Cambridge. With the generous support of Leonard Eyles, the same person who had sponsored me at CH, I arranged to spend six months in Paris, following courses in French civilisation at the Sorbonne. This was a formative experience for me. It was the first time I lived independently away from home or school; it was my first extended stay outside the UK; and it was the first time I found myself in a social environment where most of my peers were from another country and female. I roomed with a French family in a high-rise block in the 20th arrondisement, and spent much of my time walking around Paris, visiting museums and galeries, and hanging out in cafes. A particular memory is of the night when the old market in the centre of Paris ("Les Halles") was closed. There were crowds everywere with people dancing in the streets to an impromptu band sitting on the Fontaine des Innocents. I ended my stay in Paris with a life-long interest in French language, cooking, literature, art and culture.

Once in Cambridge, I settled quickly into college life, getting exercise by playing squash and by rowing with the proud and rather traditional Jesus College Boat Club. As at school, I was not a particularly adept sportsman and never rose higher than stroke in the second boat, but we held our own and several times "bumped" the first boat of another college in the Lent and May races. Regular rowing (up to six times a week) built up a level of fitness which has served me well for the rest of my life. At this time Jesus was an all male college, and social life revolved around sports, musical activities and the college bar. To get some broader experience, I volunteered for Children's Holiday Venture, a charity which ran holiday camps for disadvantaged German children. CHV was founded in the 1950's to help refugee children, but by the early 1970's it was taking socially disadvantaged 7 to 14 year-olds from cities like Karlsruhe and Mannheim for two-week camping holidays in the Black Forest. Today it seems extraordinary that a group of foreign students would be allowed to take charge of 25 troubled children without "professional"supervision, but, in fact, it worked well with only occasional crises such as an overturned storm lantern burning down a tent, or a distraught

nine-year-old running away into the German night. By my third summer, I was co-leader of my camp, my first significant "leadership" experience. These camps greatly improved my spoken German, as well as providing a platform for long tours through continental Europe with a minivan and a tent.

I enjoyed most of the courses I took as part of the Mathematics Tripos and understood them well enough to get a low to middling first in the exams which ended each year. However, it became clear to me that my mathematical skills were not at the level of those of the best of my peers, and that my main interest was in physical science. When I decided to spend a fourth year in Cambridge to take Part III of the Maths Tripos, then the university's entrance filter for research in maths and physics, I signed up for courses in plasma, fluid and stellar dynamics and in General Relativity. I was particularly enthused by a stellar dynamics course from Donald Lynden-Bell. I had also been impressed by a visit to the Institute for Astronomy, a light, airy building designed by Fred Hoyle himself, surrounded by trees, lawns and daffodils, and contrasting strongly with the Department of Applied Mathematics and Theoretical Physics which was housed in a dingy basement in the centre of town. Thus, when Donald offered me a PhD place at the IoA, I gladly accepted.

First, however, I spent a year in Toronto, taking a Master's degree under the tutelage of Sidney van den Bergh. This gave me a thorough grounding in observational astronomy and allowed me to spend three weeks in Chile on an observing project which led to my first publication, a photometric study of the young star cluster NGC 2439. This trip was quite exciting since I arrived a few weeks after the coup against Salvador Allende and bands of young, heavily armed and apparently very nervous soldiers were patrolling all the population centres. It was a relief to get to Las Campanas and spend 15 photometric nights alone with the UoT 24" telescope. During my year in Toronto, I became interested in the mystery of the "missing mass" and formulated what would become the main project for my PhD, an exploration of whether the dark matter in galaxy clusters could be bound to the individual galaxies. When I got back to Cambridge, Donald Lynden-Bell was happy with this idea, and although we had many stimulating discussions on a very broad range of topics, we ended up never actually collaborating on a paper.

I began my PhD work with a couple of papers studying the evolution of clusters under the effects of dynamical friction and with my first computer experiment, a simulation of cluster formation with all the mass attached to galaxies. The latter was carried out using an N-body code written by Sverre Aarseth for the study of star clusters. At the time the IoA had no access to graphical output devices, so I had to follow my simulation's progress using "pictures" made on a line-printer. Finishing my thesis early, I spent my last few student months simulating galaxy mergers after a chance conversation with Alar Toomre convinced me that it was necessary to show that encounters and mergers might produce objects resembling elliptical galaxies. I also spent a summer working with Martin Rees on what has since become the standard paradigm for galaxy formation, the cooling and condensation of gas within massive halos that grow through the gravitational aggregation of pre-existing dark matter.

Over the next six years, I had postdocs in Berkeley and Cambridge and made extended visits to the National Radioastronomy Observatory, the Institute for Advanced Study, the Institut d'Astrophysique de Paris and the Institute for Theoretical Physics in Santa Barbara. This was a particularly productive and stimulating period for me. The astrophysical theory group in Berkeley was very active at the time, and attracted a stream of excellent postdocs, many of whom became friends and collaborators. During my first year in Berkeley, I met Judith Jennings, a Californian engineer who got me enthusaistically involved in the Bay Area's English folk-dance scene. We finally got married in 1984. The following year (1979) back in Cambridge as a Research Fellow

at Churchill College, I met Carlos Frenk, then a graduate student at the IoA, who became a life-long friend and my closest collaborator. During this period my half-brother was killed in a motorcycle accident. Since my step-father had died a few years earlier, I was left as my mother's only relative. A year later I was back in Berkeley, living with Judy, when Carlos arrived as a postdoc. Together with Marc Davis, we carried out simulations which showed that the galaxy distribution in a universe where the dark matter was made of neutrinos could not be compatible with the real galaxy maps which Marc had produced earlier. To me, this has always seemed one of the most significant of my results, since it showed that the main component of cosmic structure is not any known kind of matter.

Morris dancing in Berkeley, 1987

At about this time we realised that Aarseth's star cluster codes were not well-suited for studies of cosmic structure formation, so we teamed up with George Efstathiou who had adapted a plasma physics code for this problem. This allowed the matter distribution to be represented by many more simulation "particles" within an expanding cubic region subject to periodic boundary conditions. We also figured out how to represent accurately the initial conditions predicted to emerge from the early universe. These depend strongly on the density and nature of the dark matter, and once neutrinos were excluded we moved on to a possibility first proposed by Jim Peebles - a new kind of weakly interacting elementary particle, so-called Cold Dark Matter (CDM), for which thermal motions at early times would be much smaller than predicted for neutrinos. Our simulations of CDM universes came together at a landmark three-month programme at the Institute of Theoretical Physics in a paper often referred to as DEFW. A good match to Marc's galaxy maps turned out to be possible in the CDM case. Interestingly, this first paper included a model with cosmological parameters close to those that, 15 years later, turned out to be correct. However, at the time the prejudice against a cosmological constant was so strong that we concentrated on the "standard" CDM model, in which the universe is Einstein-de Sitter and the galaxy distribution is strongly biased, a concept which also emerged from this same 1984 ITP programme

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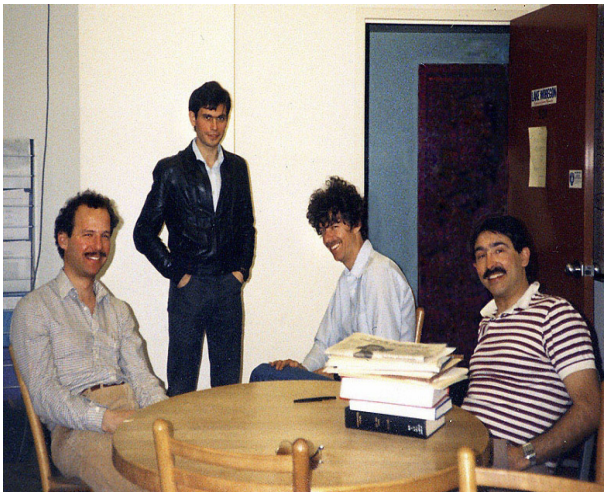

Davis, Efstathiou, White and Frenk in Berkeley, 1983

Although the CDM hypothesis was viewed with scepticism in the 1980's, it had enough impact that I was offered a tenured faculty post at the University of Arizona in 1984. This offered some consolation for an unsuccessful application for a Berkeley position, which instead went to a planetary astronomer. Judith and I therefore moved to Tucson and gained an appreciation for the extremes and the rugged beauty of the Sonoran desert. I also took advantage of the academic environment to expand my observational experience and to work with some of the strong, observationally inclined students who were attracted to Steward Observatory. Within a few years I had been promoted to Full Professor and the theoretical astrophysics programme in Arizona had grown substantially, with colleagues like Craig Hogan, Ramesh Narayan, Jonathan Lunine and Adam Burrows all moving to Tucson, at least for a few years. In addition, our DEFW collaboration continued to explore structure formation in CDM universes, establishing many of the numerical tools that would become standard in this rapidly expanding subfield. By the end of the decade, however, I had become unhappy with Tucson and irreconcilable tensions had arisen in my marriage, so in 1990 I returned to Cambridge as Sheepshanks Reader at the IoA. This was a less senior post than the one I left and had a substantially lower salary, but it felt simultaneously like a new beginning and a return to my "roots".

At IoA, I continued working with Carlos, by this time a Reader at the University of Durham, to put my early galaxy formation ideas into a CDM context. This programme was extended by my student, later my second wife, Guinevere Kauffmann to create "semi-analytic modelling", a technique for following the formation and evolution of the galaxy population as a whole within the CDM paradigm. Later developments of this programme, both in Munich and in Durham, allowed us to populate large cosmological simulations with galaxies, culminating in the well-known Millennium Simulation of 2005. It is a curious fact that although semi-analytic modelling is often disparaged as "parameter fitting", somehow less reputable than hydrodynamics-based simulation of galaxy formation, it was until very recently the only simulation scheme able to predict population properties in reasonable agreement with observation and hence to provide an interpretative link between the distributions of galaxy properties seen in surveys at high and at low redshift. A consequence is that its results have been much used and almost all the most highly cited theoretical papers on galaxy formation are based on such modelling.

By 1994 I had been passed over twice for promotion back to Full Professor, despite assurances before leaving Arizona that this would essentially be a formality. Thus, when I was head-hunted by the Max Planck Society as a possible director for their astrophysics institute, I was well primed to think about another move. At the time, the Max Planck Institute for Astrophysics (MPA) in Garching was quite a small institute, devoted to theoretical and computational astrophysics, with relatively few students, postdocs or non-German scientists, and with little cosmology or extragalactic astrophysics. However, it appeared to have excellent potential because of its location next to the headquarters of ESO and the MPI for extraterrestrial Physics, as well as excellent computational facilities and a stable funding environment. In addition, Guinevere and I liked Munich and the MPG-owned house we were offered next to the English Garden, so in late 1994 we moved to Germany.

The first few years in Munich were very active. I reorganised the institute to be more similar to those I was familiar with, setting up regular faculty meetings, advertising all postdoctoral positions internationally, instituting "scientific coffee" every morning, starting a weekly Joint Astronomy Colloquium for the Garching site, and converting the institute leadership from a single permanent director to a Board of Directors with rotating management responsibility (this was standard at other MPIs). Within a couple of years Rashid Sunyaev and Wolfgang Hillebrandt had joined me as MPA

NFW profiles in 2011 (photo G.Tormen)

directors. This period was also scientifically productive. I had met Julio Navarro in the late 1980s when (as an undergraduate!) he invited me to lecture at a summer schol in Argentina. Later he was a postdoc first with me at IoA and then with Carlos in Durham. We worked together initially on simulating the formation of individual galaxies from CDM initial conditions, then on what has turned out to be my most highly cited work, a set of papers showing that dark matter halos have a simple "universal" structure which is closely related to the properties of the universe in which they form, and hence can be used both to check the CDM paradigm and to estimate cosmological parameters.

For Guinevere, as a junior scientist married to and working with the institute director, it was difficult to establish an independent profile. In addition, our son Jonathan was born in 1996, and my mother had a serious stroke in 1998 which meant that we all had to spend time in England arranging care to deal with her gradually deteriorating health; she finally died in 2000. After a few years spent creating ever more realistic semi-analytic models, Guinevere turned to the systematic use of large galaxy surveys, in particular, the Sloan Digital Sky Survey, to constrain galaxy formation physics. This led to a series of high-impact papers where her primary responsibility was obvious to all, leading to a Leibniz Prize in 2007, to election to the US National Academy of Sciences in 2012, and to appointment as scientific director at MPA in 2013. Over this same period, I also gradually accumulated a number of prizes, as well as the other accolades that come towards the end of a successful career, election to the Royal Society in 1996, to the German National Academy, Leopoldina in 2005, as a Foreign Associate of the US National Academy of Sciences in 2007 and of the Chinese Academy of Sciences in 2015

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Guinevere, Simon and Jonathan. 2003

For two decades my MPA group and I have worked with collaborators world-wide, in particular, within the Virgo Supercomputing Consortium which Carlos and I set up to link our research programmes in Durham and Garching, to produce ever more realistic simulations of cosmic structure formation. This programme would have been impossible without my former MPA student, Volker Springel who created much of the necessary software infrastructure and carried out some of the highest impact simulations, in particular, the Millennium Simulation. In 2017 Volker was appointed scientific director at MPA as my successor. For 40 years I have been been lucky to ride a tidal wave of progress both in numerical simulation technology and in our understanding of cosmic structure formation. This has been extraordinarily exciting, and I am grateful to the Max Planck Society for providing an ideal context for the second half of this career. On June 24 2016, the day after the Brexit vote, I filed papers for German citizenship.

With Volker Springel and the machine that ran the Millennium Simulation, 2005

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