Supervision of the Proposal

A supervisor with versatile background and skills is needed to bring Dr. Scott's ambitious research proposal to fruition. My combination of expertise in theoretical cosmology and particle physics is the strongest reason Dr. Scott chose to come to McGill instead of four other competing institutions (including the offer of a named fellowship at the Harvard Center for Astrophysics). Dr. Scott's work is very much at the interface of these two fields. Although there are many potential supervisors who could lead on the astrophysics/cosmology front, the guidance of an eminent particle phenomenologist is also essential for the seminal aspect of his proposal: comparing predictions of broad classes of particle physics models for the identity of dark matter (DM).

My current research interests strongly overlap those of Dr. Scott, and I can provide essential guidance to him in the course of his research program. We have been intensively discussing the intricacies of DM model building during the planning stages of our collaboration, which we are now beginning in earnest. Much of the proposal relates to DM candidates from the Minimal Supersymmetric Standard Model (MSSM), which was the framework where I made formative contributions to the theory of electroweak baryogenesis [1]-[7] (656 citations). This work was carried out partly at CERN and tested to a great extent by the CERN LEP and Tevatron experiments, through their searches for the Higgs boson, light neutralinos, and top squarks. It kept my finger on the pulse of these experimental developments, which continue to unfold at CERN's Large Hadron Collider (LHC), and will undoubtedly play a key role in the global fits program that Dr. Scott is proposing. Part of his present proposal is to explore models that can accommodate both electroweak baryogenesis and DM, so my expertise will be indispensable in this aspect. Moreover, I have long-standing connections to the CERN theory group, which I am currently visiting, and where I have a been a Scientific Associate in 2002-2003 and 2010; these will facilitate Dr. Scott's accessibility to latest results from the LHC as they come (for example via the Collider Crosstalk forum), well in advance of the official publications. Further leadership on the particle theory side was demonstrated by my election to the council of the Institute for Particle Physics (Canada) for a three year term in 2006.

Since 2009, inspired by exciting experimental indications of indirect DM detection in our Galaxy, my research has focused primarily on the study of hidden sector DM models for explaining cosmic ray anomalies and hints of direct DM detection [8]-[16]. DM in this class of models has quite different properties from the MSSM DM candidates previously studied by Dr. Scott, and my experience here will be vital for extending the global fits programs to include these kinds of models, especially ones in which the DM has isospin-violating interactions with nuclei [15, 16]. I am also an expert on the possible effects of substructure in the DM halo [11, 14], which can be useful for understanding the constraining power of *Fermi*-LAT gamma-ray observations on these models, as well as relevant issues concerning the behaviour of the DM halo in the Galactic centre [10, 12]. A new collaboration with P. Martin of MPE, Munich will allow us to access 511 keV observations of the INTEGRAL/SPI experiment directly, and thus use this more effectively as one of the constraints we can impose on DM models in Dr. Scott's global analysis program.

My proficiency in theoretical cosmology has always been directed toward phenomenological issues, of relevance to Dr. Scott's proposal, such as understanding possible features in the cosmic microwave background (CMB) [17]-[20], and comparison of predictions of theoretical models of inflation to current data [21, 22]. The CMB provides crucial constraints on DM models, especially light DM, which can change the reionization history of the early Universe through its annihilation. These constraints figure prominently in Dr. Scott's proposal. I have been a principal organizer of cosmology conferences of international stature at the Aspen Center for Physics (2002) and the Banff International Research Station (2004). I was Principal Investigator for the FQRNT team grant on the Dark Energy of the Universe ($206k, 2005-2007). I was an invited speaker at the international conferences COSMO '08 (Madison) and The Dark Universe (Heidelberg, 2011). My accomplishments in these areas were recognized by the early award of full professor status in 2006, and a visiting scientist position with the cosmology and particle theory groups at Perimeter Institute during the latter half of 2010.

Departmental Synergy

Our department provides a remarkable synergy of research efforts that meaningfully overlap with Dr. Scott's research proposal. Within our group, we have the benefit of Robert Brandenberger's internationally recognized leadership in fundamental aspects of theoretical cosmology. In theoretical astrophysics, Gil Holder (with whom Dr. Scott and I have both collaborated) is extremely active in CMB physics, whose relevance to Dr. Scott's interests I already emphasized. Likewise in experimental astrophysics, Matt Dobbs is a leading figure on new experiments (the South Pole Telescope and POLARBEAR) to measure CMB polarization. In experimental high-energy astrophysics, David Hanna's and Ken Ragan's work on the VERITAS experiment provides another constraint on the properties of DM by its possible annihilation in nearby astrophysical objects, such as dwarf galaxies. Of course the postdocs and students working in these groups greatly multiply the opportunities for fruitful interactions.

Professional, Research and Career Support

Dr. Scott is already performing at an extremely high level for a postdoc at such an early stage of his career, and the extra research skills and connections that he can acquire with my assistance will help to assure his evolution toward a position of leadership at the highest levels. He is developing his grant-writing skills by giving me feedback on my own proposal for a renewal. He will more easily establish relationships at CERN and Perimeter Institute via my already existing links to those institutions. I can help him to obtain access to significant computational resources with CLUMEQ, a local research consortium for high performance computing. I will be able to mentor him during the process of interviewing for permanent positions, which could very well begin before the end of his tenure at McGill. I can also help him to hone his teaching skills, which will give him an edge in the keen competition for tenure-track jobs.

A very direct advantage that I am able to offer to Dr. Scott stems from my having a relatively large number of graduate students (six), some of whom are already well-versed in DM physics, others of whom are new to the field and eager to start learning and contributing. Ph.D. student A. Vincent has already been collaborating with him on a project about DM effects in the Sun, and M.Sc. student Grace Dupuis is starting work with Dr. Scott on DM annihilation in the Galactic centre. I will try to recruit one or two new students in the next year to compound these efforts. In addition to providing this manpower toward the realization of his ideas, we offer generous funding toward research expenses of $10k per year, including the expenses of visits by external collaborators. In short, we are quite fortunate to have Dr. Scott in our department, and I will continue to do all that is possible to further his development and research goals.

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Professor of Physics

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