Wesley C. Fraser
Ph.D. in Astrophysics
H index = 22
1,200 Citations

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Thesis

The Size Distribution of the Kuiper belt: Constraints on Accretion

I have performed multiple wide and deep optical ecliptic Kuiper belt surveys on the Canada-France Hawaii and Subaru telescopes. The sample of 107 Kuiper belt objects I discovered was used to measure the Kuiper belt size distribution. The size distribution is well described by a broken power-law that is steep for the largest objects that breaks to a much shallower slope at D~200 km. The creation of which required a prolonged collisional evolution that has disrupted bodies as larger as the roll-over diameter. A numerical collisional evolution model developed by myself was used to calculate the evolution of the size distribution through collisional processing. I found that creation of the break through collisional processing is not possible in the current Kuiper Belt. Rather, the early Kuiper Belt was at least an order of magnitude more massive and experienced a heightened dynamical state. The belt must have underwent a basic history as follows:

After a short period of quiescent planet growth in a dynamically cold disk lasting no more than roughly 100 Myr, some event - likely the migration of the gas-giant planets - stirred up the belt and emplaced objects onto excited orbits comparable to what we observe today. This caused mutual collisions to be catastrophic rather than accretional, halting growth, and resulting in a massive collisional disruption event. This phase of enhanced collisional comminution lasted no more than 100 Myr, and modified the size distribution for all but the largest objects. After the size distribution attained a shape similar to that observed, a rapid mass depletion occurred, effectively halting the collisional evolution. The belt we see today is the remnant of this history and has evolved minimally since the epoch of mass depletion.

Most Significant Contributions to Research

Fraser, W. C., Bannister, M. T., Pike, R. E., Marsset, M., Schwamb, M. E., Kavelaars, J. J., Lacerda, P., Nesvorný, D., Volk, K., Delsanti, A., Benecchi, S., Lehner, M. J., Noll, K., Gladman, B., Petit, J.-M., Gwyn, S., Chen, Y.-T., Wang, S.-Y., Alexandersen, M., Burdullis, T., Sheppard, S., and Trujillo, C. *"All Planetesimals Born Near the Kuiper Belt Formed as Binaries"* Nature Astronomy, vol. 1E, 88F. 21 citations.

Through high resolution imaging and optical colour measurements, we discovered a new class of planetesimal that consists entirely of binary pairs. These binaries exhibit unique surface properties compared to their surroundings. We demonstrated through numerical simulation that these binaries are the survivors of a push-out process. Critically, the presence of this population requires that Neptune's outward migration was smooth, and not explosive as has been suggested. Astonishingly, these results demonstrate that objects that formed in the Kuiper Belt region must have formed almost exclusively as binary pairs, a previously unrealized phase of the planet growth process.

Fraser, W. C., Brown, M. E., Morbidelli, A., Parker, A., and Batygin, K. "*The Absolute Magnitude Distributions of Kuiper Belt Objects*", 2014, The Astrophysical Journal, vol. 782, 100F. 104 citations.

We compiled all useable survey data to measure the absolute magnitude distributions of the dynamically excited (hot) and quiescent (cold) Kuiper Belt Objects (KBOs). We found that their distributions, are formally incompatible. The hot objects however, possess an absolute magnitude distribution indistinguishable from that of the Jupiter Trojans. Our results are in agreement with predictions of the Nice model in which the hot KBOs and Trojans originated from the same primordial population, and thus share the same size distribution. Our results demonstrate that the cold population however, does not share the same origins as the Trojans.

Fraser, W. C., and Brown, M. E. "*The Hubble Wide Field Camera 3 Test of Surfaces in the Outer Solar System: the Compositional Classes of the Kuiper Belt*", 2012, The Astrophysical Journal, vol. 749 33 F. 53 citations

We acquired substantial HST photometry from which we were able to develop a simple mixing model framework which successfully explained the enigmatic surface properties (colour, composition, albedo) of small Kuiper Belt Objects. This model lead to the hypothesis that the compositions of Kuiper Belt Objects were not a result of formative processes, but a result of their residence locations within the primordial disk.

Fraser, W. C. "*The Collisional Divot in the Kuiper Belt Size Distribution*" 2009, The Astrophysical Journal, vol. 706, pg. 119F. 34 citations.

In this work I demonstrated that the break in the size distribution of Kuiper Belt Objects can be collisionally generated within the framework of the preferred formation model of the outer Solar System. Specific features of the size distribution predicted to exist by my model have recently been detected providing the first direct evidence that the Solar System evolved according to my model's predictions.

Science Programs and Collaborations

Gemini Telescope Large Program, Col-OSSOS: The Colours of the Outer Solar System Origins Survey
Principal Investigator of the ColOSSOS Large Program on the Gemini-North and Canada-France-Hawaii Telescopes. I have been awarded 386 on Gemini North and ~150 hours on CFHT between 2014 and 2019. Observing activities have started. The program will characterize the surfaces of ~100 Kuiper Belt Objects discovered by the Outer Solar System Origins Survey.

Large Synoptic Survey Telescope, Solar System Science Collaboration, UK
Point of Contact I remain the UK representative to the LSST Solar System Science collaboration, acting as liaison between the North American and UK groups. I am also the PI of a Science and Technologies Funding Council grant to develop LSST software for the manipulation of moving object observations of the LSST.

Occultations Science Team of the Outer Solar System Origins Survey
Science Team Leader for the Occultations group of the Outer Solar System Origins Survey. The purpose of the group is to predict and observe stellar occultations by targets discovered in OSSOS.

Surfaces Science Team of the Outer Solar System Origins Survey
Science Team Leader for the Surfaces group of the Outer Solar System Origins Survey. The purpose of the group is to characterize the surface compositions of Kuiper Belt Objects discovered by the OSSOS.

ATLAS Probe Solar System Science Lead
The Astrophysics Telescope for Large Area Spectroscopy (ATLAS) Probe is a mission concept proposed for the NASA probe-class space missions. I am the leader of the Solar System Science Team.

Academic Background

Degree	School	Location	Date
Ph. D. Astrophsyics	University of Victoria	Victoria, BC	Sept. 2008
BSc. H. (Theoretical Physics)	McMaster University	Hamilton, ON	April 2004

Fellowships, Awards, and Scholarships

Title	Institution	Date
Queen's Research Fellow	Queen's University, Belfast	Aug 2015 - Current
Plaskett Fellow	Herzberg Institute of Astrophysics	Sep-2011 - Aug 2015
Canadian Graduate Scholarship Doctoral	National Sciences and Engineering Research Council of Canada	Sep-2006 - Aug-2008
Graduate Student Scholarship	National Research Council of Canada	2006 - 2008
Canadian Graduate Scholarship Masters	National Sciences and Engineering Research Council of Canada	Sep-2004 - Aug-2006

Complete Refereed Publications List

Schwamb, M. E., **Fraser, W. C.,** Bannister, M. T., Marsset, M., Pike, R. E., Kavelaars, J. J., Benecchi, S. D., Lehner, M. J.;,Wang, S.-Y., Thirouin, A., Delsanti, A., Peixinho, N., Volk, K., Alexandersen, M., Chen, Y.-T., Gladman, B., Gwyn, S. D. J., Petit, J.-M. *"Col-OSSOS: The Colours of the Outer Solar System Origins Survey",* 2019, Astronomical Journal Supplements, 243, 12S

Marsset, M., **Fraser, W. C.,** Pike, R. E., Bannister, M. T., Schwamb, M., E., Volk, K., Kavelaars, J. J., Alexandersen, M., Chen, Y.-T., Gladman, B. J., Gwyn, S. D. J., Lehner, M. J., Peixinho, N., Petit, J.-M., Wang, S.-Y., *"Col-OSSOS: Color and Inclination Are Correlated throughout the Kuiper Belt"*, 2019, Astronomical Journal, 157, 94M

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Bannister, M. T., Gladman, B.J., Kavelaars, J. J., Petit, J.-M., Volk, K., Chen, Y.-T., Alexandersen, M., Gwyn, S. D. J., Schwamb, M. E., Ashton, E., Benecchi, S. D., Cabral, N., Dawson, R. I., Delsanti, A., Fraser, W. C. and 21 co-authors. *"OSSOS. VII. 800+ Trans-Neptunian Objects—The Complete Data Release"*, 2018, The Astrophysical Journal Supplement Series, vol. 236, 18B.

Holman, M. J., Payne, M. J., **Fraser, W. C.,** and 33 co-authors. *"A Dwarf Planet Class Object in the 21:5 Resonance with Neptune"*, 2018, Astrophysical Journal Letters, 855L, 6H.

Fitzsimmons, A., Snodgrass, C., Rozitis, A., Yang, B., Hyland, B., Seccull, T., Bannister, M., **Fraser, W. C.,** Jedicke, R., Lacerda, P. *"Spectroscopy and thermal modelling of the first interstellar object 1I/2017 U1 'Oumuamua",* 2018, Nature Astronomy, 2, 133F.

Bannister, M. T., Schwamb, M. E., **Fraser, W. C.,** Marsset, M., Fitzsimmons, A., Benecchi, S. D., Lacerda, P., Pike, R. E., Kavelaars, J.J., Smith, A. B., Stewart, S. O., Wang, S.-Y.; Lehner, M. J. *"Col-OSSOS: Colors of the Interstellar Planetesimal 1I/'Oumuamua",* 2017, Astrophysical Journal Letters, 851L, 38B.

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Bannister, M. T., Shankman, C., Volk, K., Chen, Y.-T., Kaib, N., Gladman, B. J., Jakubik, M., Kavelaars, J. J., **Fraser, W. C.**, Schwamb, M. E., Petit, J.-M., Wang, S.-Y., Gwyn, S. D. J., Alexandersen, M., Pike, R. E. *"OSSOS. V. Diffusion in the Orbit of a High-perihelion Distant Solar System Object"* , 2017, The Astronomical Journal, vol. 153, 262B.

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Fraser, W., C., Alexandersen, M, Schwamb, M. E., Marsset, M., Pike, R. E., Kavelaars, J. J., Bannister, M. T., Benecchi, S., Delsanti, A. "*TRIPPy: Trailed Image Photometry in Python*", 2016, The Astronomical Journal, vol. 151, 158F.

Muntean, E. A.; Lacerda, P.; Field, T. A.; Fitzsimmons, A.; **Fraser, W. C.**; Hunniford, A. C.; McCullough, R. W. "*A laboratory study of water ice erosion by low-energy ions*", 2016, MNRAS, vol. 462, issue 3.

Bannister, M., ++ Fraser, W. C., and 35 co-authors. "*The Outer Solar System Origins Survey. I. Design and First-quarter Discoveries*", 2016, The Astrophysical Journal, vol. 152, 70B.

Chen, Y., Lin, H. W., Holman, M. J., Payne, M. J., **Fraser, W. C.**, Lacerda, P.; Ip, W.-H., Chen, W.-P., Kudritzki, R.-P., Jedicke, R., Wainscoat, R. J., Tonry, J. L., Magnier, E. A., Waters, C., Kaiser, N., Wang, S.-Y., Lehner, M. "*Discovery of a New Retrograde Trans-Neptunian Object: Hint of a Common Orbital Plane for Low Semimajor Axis, High-inclination TNOs and Centaurs*", 2016, The Astrophysical Journal Letters, vol. 827, 24C.

Parker, A., Pinilla-Alonso, N., Santos-Sanz, P., Stansberry, J., Alvarez-Candal, A., Bannister, M., Benecchi, S., Cook, J., **Fraser, W.**, Grundy, W., Guilbert, A., Merline, B., Moullet, A., Mueller, M., Olkin, C., Ragozzine, D. "*Physical Characterization of TNOs with the James Webb Space Telescope*" 2016, Publications of the Astronomical Society of the Pacific, vol. 128, 8010P.

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Brown, M. E., Ragozzine, D., Stansberry, J., and **Fraser, W. C.** "*The Size, Density, and Formation of the Orcus-Vanth System in the Kuiper Belt*", 2010, The Astronomical Journal, vol. 139 pg. 2700.

Fraser, W. C. and Brown, M. E. "*Quaoar: A Rock in the Kuiper Belt*" 2010, The Astrophysical Journal, vol. 714, pg. 1547.

Fraser, W. C. and Brown, M. E. "*NICMOS Photometry of the Unusual Dwarf Planet Haumea and its Satellites*" 2009, The Astrophysical Journal Letters, vol. 695, pg. 1F

Fraser, W. C. "*The Collisional Divot in the Kuiper Belt Size Distribution*" 2009, The Astrophysical Journal, vol. 706, pg. 119F.

Fraser, W. C. and Kavelaars, J. J. "*The Size Distribution of Kuiper belt Objects for D>10 km*" 2009, The Astronomical Journal, vol. 137 pg. 72F

Fraser, W. C. and Kavelaars, J. J. "*A derivation of the luminosity function of the Kuiper belt from a broken power-law size distribution*" 2008, Icarus, vol. 198, pg. 827F

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Grav, T., Holman, M., **Fraser, W. C.** "*Photometry of Irregular Satellites of Uranus and Neptune*" 2004, The Astrophysical Journal, vol. 612, pg. L77.

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Canadian LRP White Paper - J. Kavelaars, B. J. Gladman, A. Hildebrand, **W. C. Fraser**, R. E. Pudritz, P. Wiegert. "*Planetary Astronomy: Minor Planets and Planet Formation"* 2010 White paper for the Canadian Astronomy Long Range Plan. http://www.casca.ca/lrp2010/

Select Press and Media Interactions

BBCs - Sky at Night special on my research on 1I/'Oumuamua. Appeared on BBC 4, Sunday February 11th. Permalink: https://www.bbc.co.uk/programmes/b09rvpts

"Blue Binaries Suggest a Smooth Migration for Young Neptune." Gemini Focus issue 67, July 2017, http://www.gemini.edu/images/pio/newsletters/pdf/gf_0717.pdf

"The Night Sky and Astronomy" Reoccurring bi-weekly radio segment on CFAX Radio (BC broadcast). First recording permalink: https://soundcloud.com/saturday-programming-cfax/sep-13-cafe-victoria?in=saturday-programming-cfax/sets/saturday-programming

"Some Planet-like Kuiper Belt Objects Don't Play Nice" Universe Today, 2014 by Matthew Francis. Permalink: http://www.universetoday.com/108189/some-planet-like-kuiper-belt-objects-dont-play-nice/

Quirks and Quarks Holiday Question Show, 2013. Permalink: http://www.gemini.edu/node/12081

"Limits on Quaoar's Atmosphere" Gemini News Cast #51, 2013 by Nancy Levinson. Permalink: http://www.gemini.edu/node/12081

"Probing the Solar System's Icy Fringes" Forbes, 2013 by Bruce Dorminey. Permalink: http://www.forbes.com/sites/brucedorminey/2013/08/22/probing-the-solar-systems-icy-fringes/

"Astrophile: the Changing Face of Icy Dirt-Ball Quaoar" New Scientist, 2013 by Victoria Jaggard. Permalink: http://www.newscientist.com/article/dn23951-astrophile-the-changing-face-of-icy-dirtball-quaoar.html#.UthkQmRDtHE

"Is Densest Kuiper Belt Object a Wayward Asteroid?" New Scientist, 2010 by David Shiga. Permalink: http://www.newscientist.com/article/dn18739-is-densest-kuiper-belt-object-a-wayward-asteroid.html#.UthjrWRDtHE

Minor Planet Circulars (2 of ~100)

Schwamb, M. E., **Fraser, W. C.**, Brown, M. E., Rabinowitz, D., Marsden, B. G. "*2008 ST291*" Minor Planet Circular 2009-V68.
Fraser, W. C., Schwamb, M., Gladman, B. J., Kavelaars, J. J., Petit, J-M. Jedicke, R. Parker, J., Marsden, B. G. "*2008 KV42*" Minor Planet Circular 2009-N32.

Select LRP2020 White Papers (2 of 5)

Fraser, W .C., Graham, M. L., Kavelaars, JJ., Di Francesco J., Hložek, R., Blakeslee, J. P., Hall, P. B., McNamara, B. R. "Canadian Participation in the LSST" https://drive.google.com/open?id=1etuxee7gHyse9HJ5IWZY89cpTJSJvNpW

Lawler, S. M., Boley, A. C.; Connors, M., **Fraser, W.,** Gladman, B., Johnson, C. L., Kavelaars, J. J., Osinski, G., Philpott, L., Rowe, J., Wiegert, P., Winslow, R., "The Kuiper Belt is Weird", 2017, Armagh Observatory, "Planetary Astronomy-Understanding the Origin of the Solar System", https://drive.google.com/open?id=10gS1XTO47cs9pqHjBABvHdLlwgvcYdTt

Select Recent and Published Conference Proceedings

Invited Talk - **Fraser, W. C.,** "The Kuiper Belt is Weird", 2017, Armagh Observatory

Invited Talk - **Fraser, W. C.,** "The LSST's revolution of outer Solar System, small body science." 2016, LSST-Europe2, Belgrade, Serbia.

Invited Talk - **Fraser, W. C.,** "The Kuiper Belt through the eyes of the UVOIR space telescope.", 2016, Goddard Space Flight Centre

Invited Talk - **Fraser, W. C.,** "The binarity, composition, and a few sizes of Kuiper Belt Objects" Hubble 25th Anniversary Meeting, 2015, Space Telescope Science Institute.

Invited Talk - **Fraser, W. C.**, "Adventures in the Kuiper Belt", 2013, McGill Colloquium Series.

Invited Talk - **Fraser, W. C.**, "H/WTSOSS: Compositions of Small KBOs" 2011, Las Cumbres Observatory Global Telescope.

Fraser, W. C., and 21 co-authors, "All planetesimals born near the Kuiper belt formed as binaries", Asteroids Comets and Meteors 2017, Montevideo.

Fraser, W. C., and 13 co-authors "Col-OSSOS: A new ugrJ taxonomy for trans-Neptunian objects". 2016, Division of Planetary Sciences, AAS, AGM.

Fraser, W. C., Brown, M. E., and Emery, J. The nonlinear spectra of transneptunian objects: Evidence for organic absorption bands". Asteroids, Comets, and Meteors, 2015, Helsinki.

Fraser, W. C., Gwyn, S., Trujillo, C., Brown, M. E., Kavelaars, J., Stephens, A., Gimeno, G. "Predicting Occultations by Kuiper Belt Objects". 2013 Division of Planetary Sciences, AAS, AGM.

Fraser, W. C., Brown, M. E., Batygin, K., Bouchez, A. "Tidal Evolution of the Quaoar-Weywot System". 2012 American Astronomical Society AGM.

Employment History

Position	Supervisor	Location	Date
Contract Researcher	Dr. Mike Brown	California Institute of Technology	Nov 18 - Current
Contract Researcher	Dr. James Di Francesco	NRC-Herzberg	Nov 18 - Current
Queen's Research Fellow/lecturer	Professor Smartt	Queen's University, Belfast	Aug 2015 - Nov 2018
Plaskett Fellow	Dr. Jim Hesser	Herzberg Institute of Astrophysics	Sep-2011 - Aug 2015
Contract Researcher	Dr. Mike Brown	California Institute of Technology	June 2014 - Aug 2015
Postdoctoral Scholar	Dr. Mike Brown	California Institute of Technology, Geological and Planetary Sciences,	Oct-2008 - Sep-2011
Research Assistant	Dr. JJ Kavelaars	Herzberg Institute of Astrophysics	May-2004 - Sep-2004

Teaching Experience

Astrophysics Level 2 **2016/17 and 2017/18 - Queen's University, Belfast**

- course coordinator, responsible for complete design of course content and layout
- lecturer
- lab instructor
- exam writer

Physics for non-physicists **2003 - McMaster University**

- course lecturer
- tutorial teacher

Technical/Observational Experience

Graduate Students:

•Supervisor of 1 masters (graduated) and 3 PhD students (1 graduated, 2 on-going)

CCD mosaic imaging/Photometry:

- many observing nights on various 4+ meter telescopes including the CFHT, Magellan, Subaru, VLT, and Keck telescopes.
- extensive experience with space based observations, primarily with the HST (PI on GO 12234 and Co-I on GO 11644).

- observing experience mainly geared towards, discovery, tracking, and photometric and astronometric characterization of Solar System objects.
- main author and maintainer of the python moving object photometry package, TRIPPy - TRailed Image Photometry in Python

Optical-NIR Spectroscopy

- low resolution (R~100-1000) visible wavelength and NIR (JHK-band) spectroscopy of moving Solar System targets utilizing Keck and HST.
- high resolution (R~5000) UV/Vis/NIR spectroscopy of moving Solar System targets with the VLT+Xshooter.

Numerical Simulations/Non-observing Experience

- extensive programming experience in python, C/C++, fortran, matlab. Author/ maintainer of various python modules
- GPU computing with NVIDIA-CUDA
- mysql database experience
- Linux server administrator (Fedora, Redhat Linux, Ubuntu, Ubuntu Server)
- distributed “cloud” compute use and deployment (AWS, CANFAR)
- web development (Drupal, flask, django)
- web server administration (LAMP on Ubuntu server)
- scripting languages (python, BASH, CSHRC)

References

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