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## Marie Skłodowska-Curie Innovative Training Network “SAGEX” (Scattering Amplitudes: from Geometry to EXperiment)

We invite applications for two three-year Early Stage Researcher (ESR) PhD studentships to start between October 1<sup>st</sup> 2018 (*preferred*) and April 30<sup>th</sup> 2019 in the domains of scattering amplitudes, double-copy constructions, on-shell methods in quantum and classical field theory, and perturbative QCD. The studentships will be funded by the recently awarded MSC Innovative Training Network (ITN) SAGEX (Grant no. 764850). SAGEX is a unique consortium that combines an international team of academic leaders in the research area of scattering amplitudes with a selection of world-leading industrial partners.

These two ESRs will be held at the [Institute for Theoretical Physics \(IPhT\)](#) at Saclay in the Paris suburbs, with secondments to partner institutions across Europe and the United States, as well as commercial partners. The IPhT is one of the premier theoretical physics research institutes in Europe. Its globally recognized researchers work on a broad range of topics including high-energy and mathematical physics, cosmology, astro-particle physics, condensed matter, and biophysics.

Accepted applicants will pursue a PhD degree to be awarded by the Université Paris–Saclay in one of two subjects: (a) **Local loop-level recursion for nonplanar theories** toward many applications including high precision solutions to classical gravitational radiation, supervised by Drs. Carrasco and Kosower, and (b) **Two-loop QCD amplitudes for next-to-next-to-leading order calculations at the LHC**, supervised by Dr. Kosower. Additional information is available at the SAGEX web site <https://sagex.ph.qmul.ac.uk/>. Details of ESR projects and secondments are provided below. The monthly stipend of the studentship will typically be around €2300 (gross) per month with €400 (gross) mobility allowance per month, and a family allowance (if applicable).

As part of the MSC ITN, there are strict eligibility requirements. At the time of appointment, an applicant must not have resided or carried out his or her main activity (work, studies) in France for more than 12 months in the three years immediately preceding the appointment; may not have been awarded a doctoral degree; and must be in the first four years of the individual’s research career. In addition, applicants must be currently enrolled in or have completed a master’s degree program in theoretical high-energy physics, and must have already completed at least one course in quantum field theory. Award of the studentship will be contingent on successful completion of the master’s degree by one month prior to the anticipated start date. In addition, applicants must be fluent (reading, writing, and speaking) in English.

Candidates must be able to demonstrate their eligibility to work in France in accordance with current French law and French hiring restrictions on academic doctoral training contracts. The SAGEX consortium encourages and actively welcomes applicants with diverse backgrounds and life experiences.

Applications should include a CV and a transcript of bachelor’s and master’s courses with grades. Applicants should arrange for two letters of reference to be submitted. If the master’s program includes a thesis or internship, the supervisor should submit a letter of reference as well.

All materials should be supplied electronically only to [ipht.sagex@gmail.com](mailto:ipht.sagex@gmail.com).

Applications and supporting material should be received by June 1, 2018 in order to receive full consideration.

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SAGEX will fund 15 early stage research projects throughout Europe. The two to be hosted at IPHT are:

SAGEX ESR No. 9
<b>Project Title:</b> Local loop-level recursion for nonplanar theories.
<b>Objectives:</b> We know through generalised unitarity methods that tree-level data encodes all necessary information for all-loop quantisation. Promoting this to analytic loop-level recursion would engender all-loop order insight through analysis of tree-level data, as well as providing a natural non-planar generalisation of the amplituhedron. For this to be useful for phenomenological theories, results must be amiable to integration and lining up with potential integral basis. This means achieving local representations. Here the power of the colour-kinematics to relate non-planar and planar information in a local graph basis has tremendous promise. It is likely sufficient to require colour-kinematics only up to edges privileged by recursion.
<b>First supervisor:</b> Carrasco. <b>Second supervisor:</b> Vanhove. <b>Mentor:</b> Bern.
<b>Milestones and expected results:</b> Establish new multi-loop-level recursion relations, starting with finite-colour theories at four-point one-loop; this will subsequently be extended to higher loops and legs with the goal of recursing up to three-loops.
<b>Planned Secondments:</b> Three months to Wolfram; short term visits to other partners (e.g.: QMUL, UCLA). Further secondment at Danske Bank, DreamQuark, Mærsk, or Milde Marketing.

SAGEX ESR No. 10
<b>Project Title:</b> Two-loop QCD amplitudes for next-to-next-to-leading order calculations at the LHC.
<b>Objectives:</b> Future studies at the LHC will require precision calculations at the next-to-next-to-leading order (NNLO) in perturbative QCD, for processes with external quarks, gluons, electroweak vector bosons, photons, and Higgs bosons. The project will implement selected unitarity-based approaches for two-loop amplitudes into the existing BlackHat library. It will include the development of necessary two-loop integral libraries. The code will then be applied to NNLO phenomenology of selected processes.
<b>First supervisor:</b> Kosower. <b>Second supervisor:</b> Carrasco. <b>Mentor:</b> Dixon.
<b>Milestones and expected results:</b> Development of a two-loop integral software library. Warmup: Reproduce the numerous known $\mathcal{N}=4$ SYM two-loop examples. Expected results: Two-loop numerical unitarity implementation; NNLO QCD phenomenology.
<b>Planned Secondments:</b> Three months to RISC; short term visits to other partners (e.g.: DESY, SLAC). Further secondment at Danske Bank, DreamQuark, Mærsk, or Milde Marketing.

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