FKPPL Project application (2012)

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ID: Title	**The PAMELA and CREAM anomalies and the new cosmic ray paradigm**

	French Group			Korean Group		
	Name	**Title**	**Affiliation**	**Name**	**Title**	**Affiliation**
List of participants	Leader: Pierre SALATI	Professor	LAPTh	Leader: Yong-Yeon KEUM	Research Professor	Seoul National University (SNU)
	Richard TAILLET	Professor	LAPTh	Sang-Gyu Byun	PhD Student	Seoul National University(SNU)
	Guilhem BERNARD	PhD Student	LAPTh			

Requested LIA specific funding from France

Description	**Euro/unit**	**Nb of units**	**Total (euros)**	**Requested to: ***
Return plane tickets from Lyon or Geneva to Seoul Incheon	800	3	2400	IN2P3
Living expenses for Yong-Yeon KEUM during a month long visit at LAPTh in Annecy	100 euros per day	30 days	3000	IN2P3
Total			5400	

Requested funding from Korea

Description	**Won/Unit**	**Nb of units**	**Total (Won)**	**Requested to: ****
Return plane tickets from Seoul Incheon to Paris	2,000,000 won	2	4,000,000	FKPPL 사업단
Living expenses for P. Salati during a month at SNU, Seoul in Korea	150,000/day	30 days	4,500,000	NRF 모험연구 신청
			8,500,000	
Total				

	Additional funding from France			Additional funding from Korea		
Additional funding	**Provided by or requested to *****	**Type**	**Euro**	**Provided by or requested to**	**Type**	**Won**

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	CNRS DR11 LAPTh and Université de Savoie	Living expenses of French team in Seoul	3000			

* For example: IN2P3, CEA. ** Korean University or Institute. *** French Embassy, CNRS Egide,……

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Summary of Project	Title: The PAMELA and CREAM anomalies and the new cosmic ray paradigm The Cosmic Ray Energetics and Mass (CREAM) experiment and the PAMELA satellite have both reported an excess in the proton and helium cosmic ray fluxes above 250 GeV/nucleon. The excess is significant between 1 and 100 TeV. This observation is interesting insofar as it may indicate that new acceleration mechanisms are at stake even for primary cosmic ray species. It may also indicate that our description of cosmic ray transport needs to be improved. The aim of this collaboration is to investigate various plausible explanations and to derive observational tests to disentangle them. In the conventional scheme, primary cosmic ray nuclei are accelerated from the interstellar medium by super nova driven shock waves and are injected with a source spectral index $\alpha \approx 2.15 \pm 0.15$. They subsequently diffuse in the galactic magnetic field. Their transport is in phenomenology described by a space diffusion coefficient $K \propto \varepsilon^{\delta}$ whose dependence on the energy ε is characterized by the diffusion index δ. The boron to carbon ratio sets constraints on the propagation of cosmic rays so that $\delta = 0.65 \pm 0.15$. The spectral index measured at the earth is the sum $\alpha + \delta$. The CREAM and PAMELA measurements may originate from a drop either of α or of δ above 250 GeV/nucleon. We suggest then to explore several directions. **(i)** A powerful tool is featured by the cosmic ray secondary to primary abundance ratios like B/C or the flux of antiprotons relative to protons. We do not expect these ratios to be significantly modified if the hardening of the spectra takes places at the source. At least, no kink should be observed. On the contrary, if the diffusion index δ decreases above 250 GeV/nucleon, the antiproton to proton and B/C ratios should feature the corresponding imprint. Once new data are available – with CREAM and the forthcoming AMS02 experiment – we plan to analyze the energy distributions of the various species in order to find if the hardening takes place at the source or during the propagation. **(ii)** If the hardening takes place at the source, we will reinvestigate the acceleration mechanism in order to explain why cosmic rays are delivered more efficiently at high energy. We will be inspired by a recently revived scenario according to which cosmic rays undergo spallation reactions while they are accelerated. This scenario naturally explains the positron excess reported by the PAMELA collaboration above 10 GeV. **(iii)** We have recently explored a new direction which we find very exciting. It is common belief to treat the sources of primary cosmic rays as if they were continuously spread in space and time. The source term in the master equation of cosmic ray transport describes a jelly which steadily accelerates protons and helium nuclei. If the sources of acceleration are actually shock waves driven by supernova explosions, they are localized in space and time. They are intrinsically discret and not homogeneously distributed. We have shown (see report for 2011) that the fluxes of primary species are dominated above a few hundreds of GeV by local and recent sources. We are on the verge of explaining the PAMELA and CREAM anomalies with the help of a catalogue which encompasses such local and recent sources (supernova remnants and pulsars). We are convinced that high-energy cosmic rays probe the local environment and that the discreteness of the sources plays a major role. If this were confirmed, cosmic ray transport at TeV energies should be completely revisited. This would be a breakthrough insofar as public codes such as GALPROP, DRAGON and the forthcoming USINE do not deal with discreteness and treat the sources of acceleration as if they were continuous in space and time. This would have also important consequences on the indirect signatures of the putative dark matter particles (WIMPs) and on their astrophysical backgrounds. **(iv)** We have already started to develop numerical analysis programs to explain the cosmic ray nuclei data from CREAM and PAMELA experiments. The propagation of cosmic ray nuclei is described by Green functions

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