# Galactic cosmic ray modulation in the heliosphere based on muon telescopes and ion chambers data

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# Abstract

We study the galactic cosmic ray modulation in the heliosphere based on muon telescopes and ion chambers data. We analyze the modulation parameters of galactic cosmic ray transport in the heliosphere retrieved from GCR anisotropy for solar cycles 18-23 and parts of 17 and 24, covering the period 1937-2018. It was found that the ratio **α** of mean free paths normal and parallel to mean interplanetary magnetic field B is polarity dependent at Earth orbit with higher values for periods around solar minima for positive polarity (A>0) than for negative (A<0). Timeline of ratio **α** for more than 7 decades, exhibits a slight ~11-year and dominant ~22-year variation and has a strongly polarity dependent character with the considerable enhancement in the minimum epoch of solar activity for A>0 magnetic polarity. Results will be confronted with current modulation theories. We examine the diffusion-convection implications and the solar cycle and solar magnetic polarity dependence of cosmic ray modulation for muon and ion chamber data.

# Experimental Data

We analyze yearly solar diurnal variations recorded by

- IC at Cheltenham for 1937-1977,
- MT data at Nagoya for 1971-2017,
- MT Hobart (Australia) for 2007-2018

# Data Analysis

$(Ar^p + Ar^n)/2 = 3/v\ (CV - KrrGr)$ (1), $Krr = K_{\parallel} cos^2\psi + K_{\perp} sin^2\psi$

$(A\varphi^p + A\varphi^n) = (1-\alpha)\ \lambda_{\parallel} Grsin2\psi$ (2), $\lambda_{\parallel} Gr = -Ar + \frac{3C}{v} + A\varphi Tan\psi$

$\boldsymbol{\alpha} = 1 - (A\varphi^p + A\varphi^n)/(\lambda_{\parallel} Grsin2\psi)$ (3)

# Results

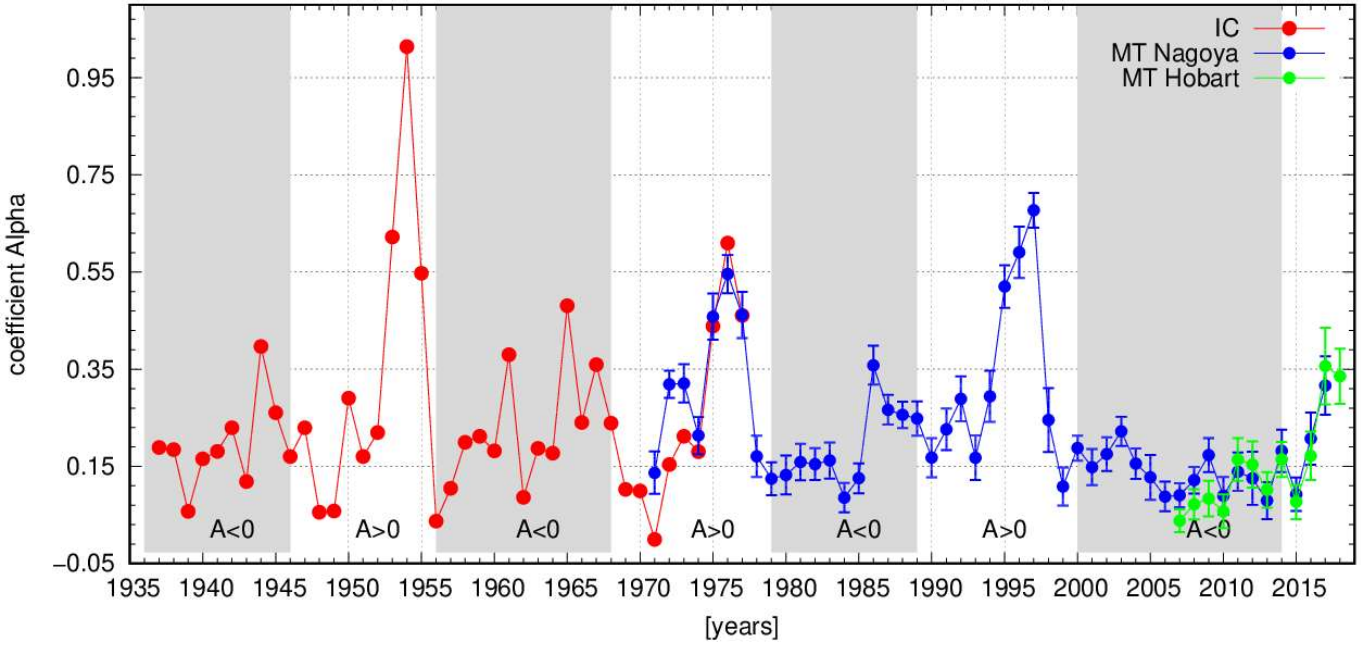


Fig. 1. Yearly ***α*** for IC Cheltenham, MT Nagoya and MT Hobart data for 1937-2018, for solar cycles 18–23 and parts of 17 and 24.

- We found that the ratio $\alpha$ is polarity dependent at Earth orbit with higher values for periods around solar minima for positive polarity (A>0) than for negative (A<0).

- Timeline of ratio $\alpha$ for more than 7 decades, exhibits a slight ~11-year and dominant ~22-year variation and has a strongly polarity dependent character with the considerable enhancement in the minimum epoch of solar activity for A>0 HMF magnetic polarity.