Microphysical Properties of Alaskan Volcanic Ash

Anin Puthukkudy[a,b,*], W. Reed Espinosa[a,b], Adriana Rocha Lima[b,c], Lorraine Remer[a,b], Peter Colarco[c] Patrick Whelley[c], Nickolay Krotkov[c], Kelsey Young[d], Oleg Dubovik[e], Kristi L. Wallace[f] & J. Vanderlei Martins[a,b]

[a]Department of Physics, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA.
[b]Joint Center for Earth Systems Technology, University of Maryland Baltimore County, 5523 Research Park DR, Baltimore, MD 21228, USA. [c]NASA Goddard Space Flight Center, Greenbelt, MD.
[d]University of Texas, El Paso/Jacobs JETS Contract at NASA Johnson Space Center, Houston, TX, 77058. [e]Laboratoire d'Optique Atmosphérique, UMR8518, CNRS - Université de Lille 1, 59655, Villeneuve d'Ascq, France.
[f]US Geological Survey, Anchorage, Alaska Volcano Observatory, Alaska 99508, USA. *Presenting author (*aputhukkudy@umbc.edu*)

UMBC AN HONORS UNIVERSITY IN MARYLAND

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Volcanic Ash

- Volcanic ash has the potential to cause a variety of severe problems for human health and the environment
- Effective monitoring of the dispersion and fallout from volcanic ash clouds and characterization of the aerosol particle properties are essential for assessing the hazard and its effect on Earth's radiation budget
- One way to acquire information from volcanic ash clouds is through satellite remote sensing
- Size distribution, sphericity and optical properties of volcanic ash are often a pre-requisite for making accurate and quantitative retrievals
- The same kind of information is also needed for atmospheric transport models to properly simulate the dispersion and fallout of volcanic ash
- The microphysical and optical properties vary significantly between eruptions, which can occur under very different conditions

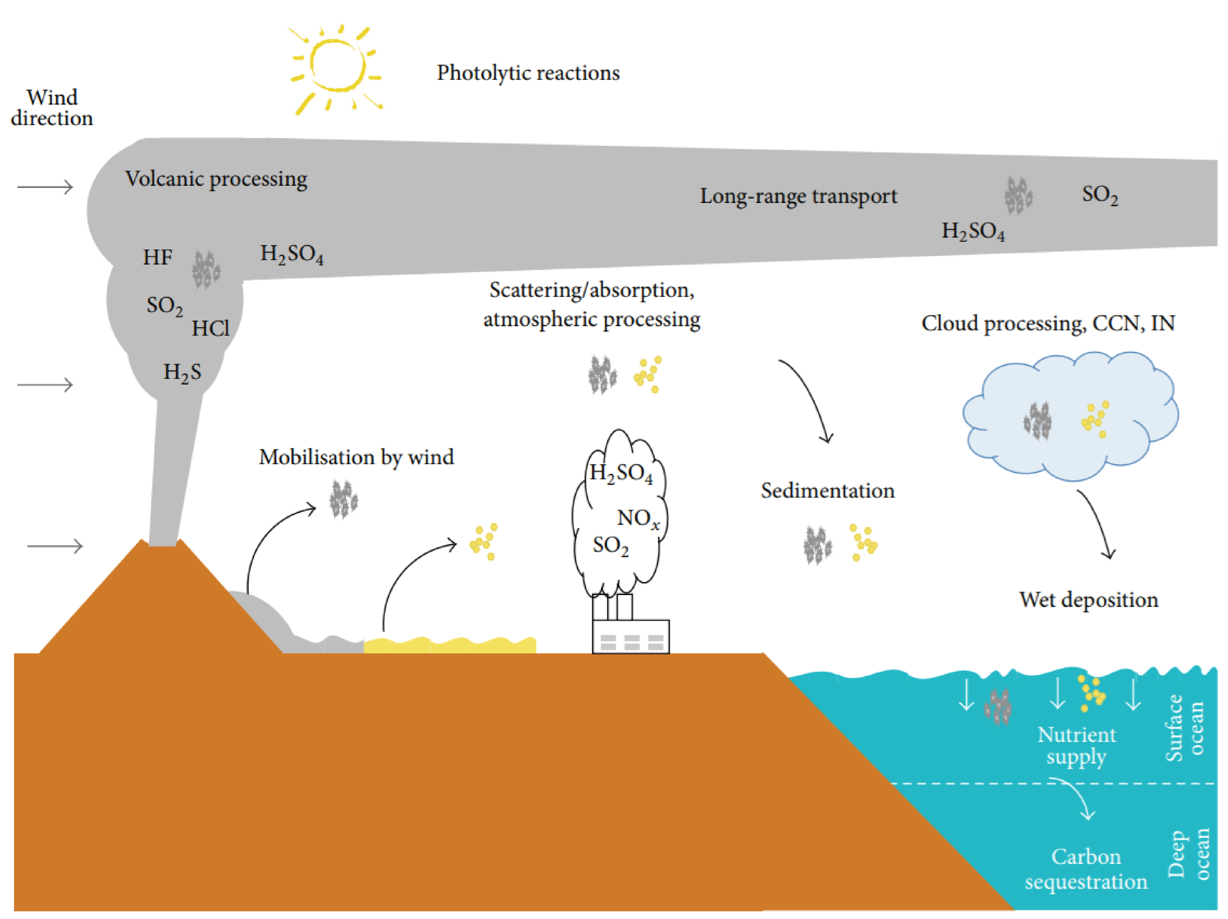

Figure 1: Schematic diagram showing the important environmental and climate effects of volcanic ash (in grey) and mineral dust (in yellow). (CCN: cloud condensation nuclei; IN: ice nuclei) [1]

Method

- Presented here is a laboratory method to determine the microphysical and optical properties of volcanic ash samples collected from two Alaskan volcanoes with markedly different compositions
- The technique uses a Fluidized bed Aerosol Generator to re-suspend ash particles that are then sampled by a CPC and polar nephelometer before being impacted on a Nucleopore Filter

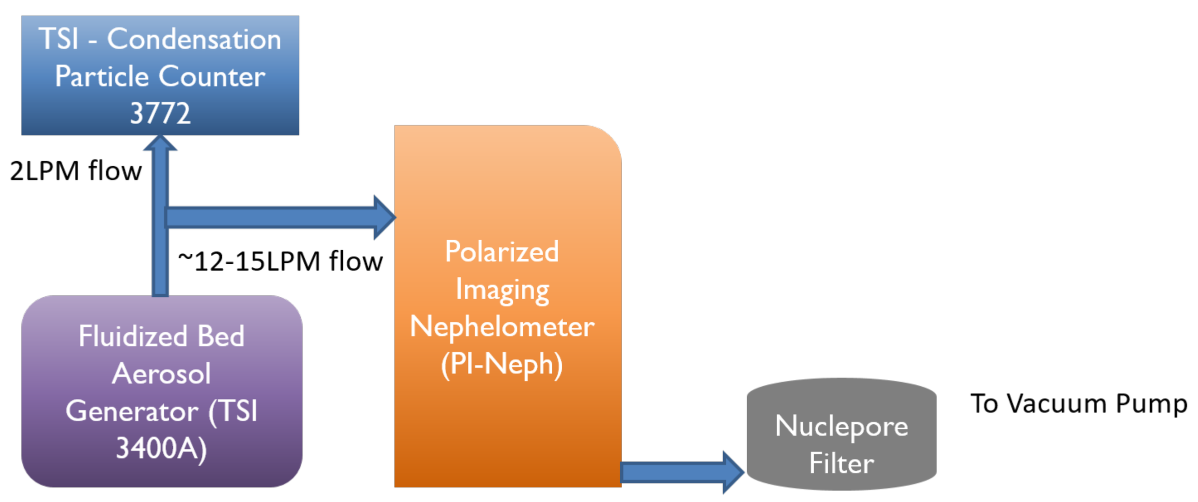

Figure 2: Schematic diagram of the experimental setup

PI-Neph (Polarized Imaging Nephelometer)

- The PI-Neph measures angular light scattering and polarization of the re-suspended particles from 3° to 175° in scattering angle, with an angular resolution of one degree [2]
- The PI-Neph uses a three wavelength laser system, polarization optics, and a wide field of view imaging camera
- Measures P_{11} and P_{12} elements of the scattering matrix
- Size distribution, sphericity and the refractive index of the aerosol will be retrieved using the GRASP algorithm [3]
- Used in NASA aircraft campaigns - SEAC[4]RS[4], DC3, DEVOTE and DISCOVER-AQ

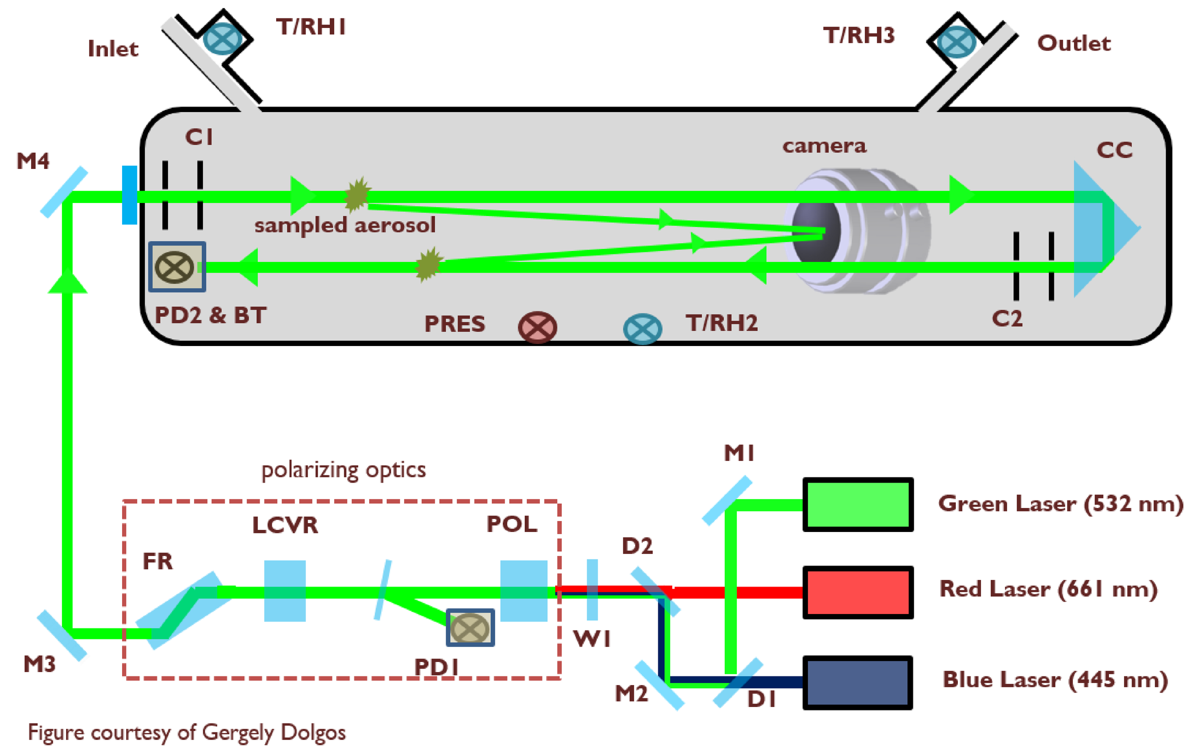

Figure 3: Polarized-Imaging Nephelometer(PI-Neph)

Samples

Mt. Okmok

- Erupted in August 2008
- Eruption had a maximum Volcanic Explosivity Index (VEI) of 4
- Basaltic andesite in composition($\sim$55-57% SiO_2)
- Sample was collected from the ground in September 2008 in Fort Glenn, AK on Umnak Island ($\sim$15km from the vent)
  – Composite of ashfall between July 12 and mid august

Katmai

Katmai/Novarupta

- Erupted in June, 1912
- Largest eruption in 20th century (VEI $\sim$ 6)
- Ash sample collected from the ground in Kodiak, AK (161 km) from the vent
- Caused measurable decrease in global temperature
- Accompanied by extreme seismic activity

Result & Discussion

Table 1: Microphysical and optical properties of Alaskan volcanic ash samples retrieved by GRASP

Sample	*Real RI* (445,532,661nm)	*Imaginary RI* (445,532,661nm)	*Sphere Fraction* (%)	*PSD* $r_v(\mu m)$, c_v
Okmok	1.53, 1.50, 1.48	0.0025, 0.0026, 0.0033	2.2	5.94, 0.48
Katmai	1.60, 1.55, 1.56	0.0003, 0.0003, 0.0003	0.6	6.94, 0.45

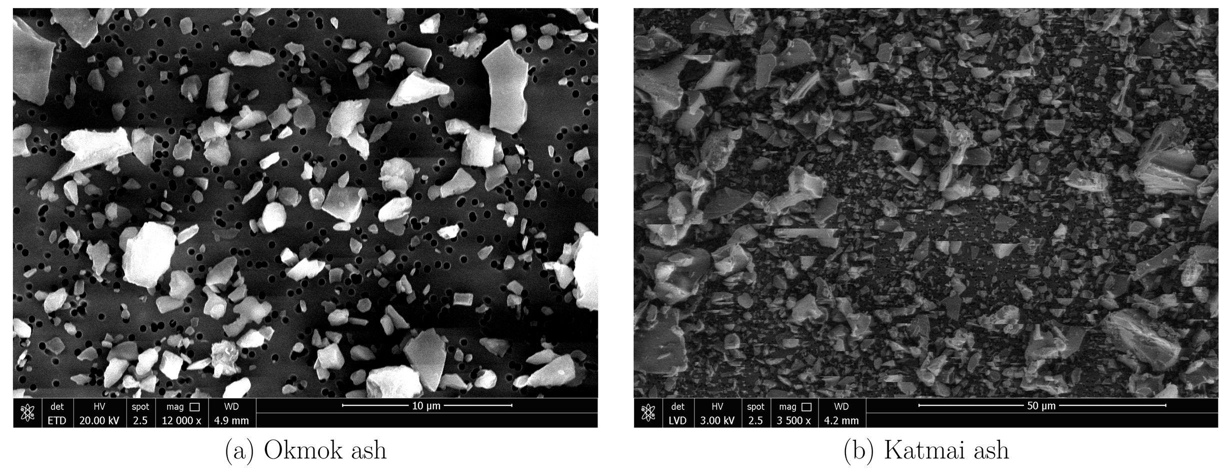

Figure 4: Scanning Electron Image of volcanic ash particles collected on a nucleopore filter

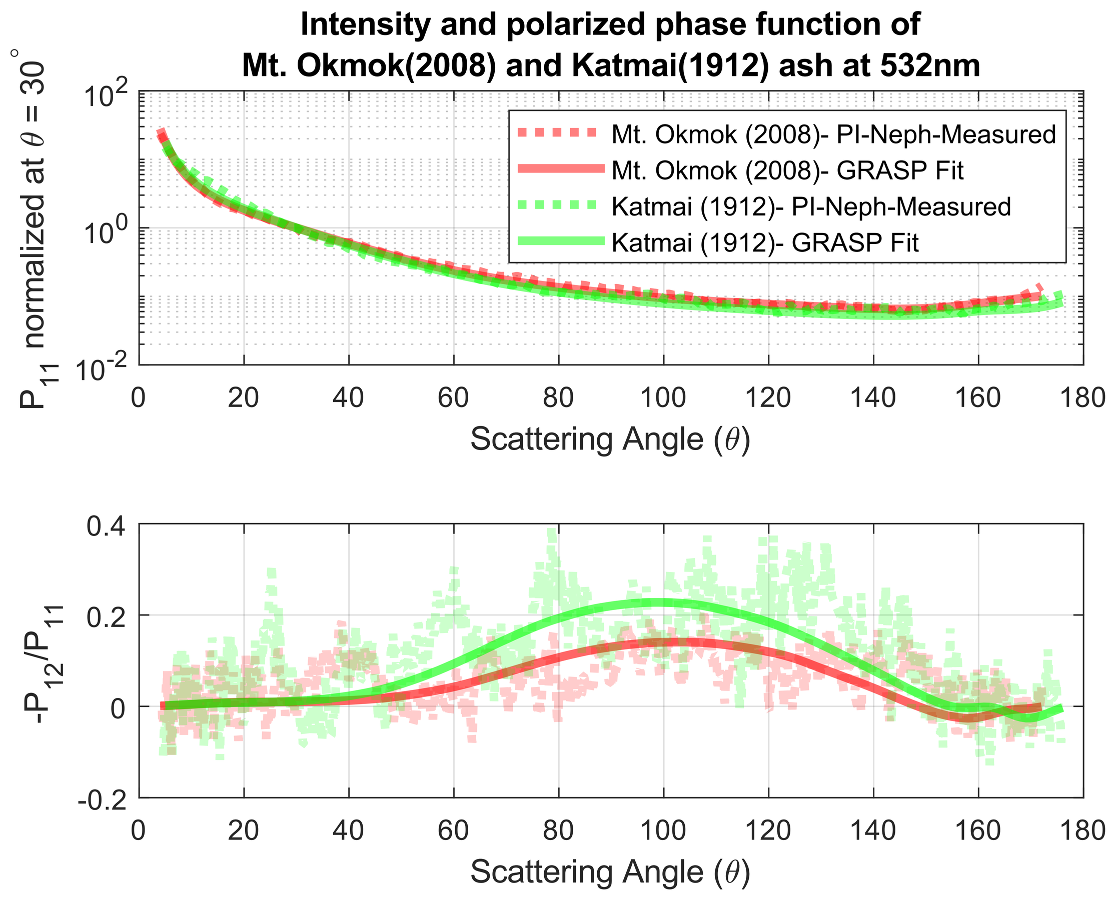

Figure 5: P_{11} and $-P_{12}/P_{11}$ of volcanic ash samples measured using PI-Neph

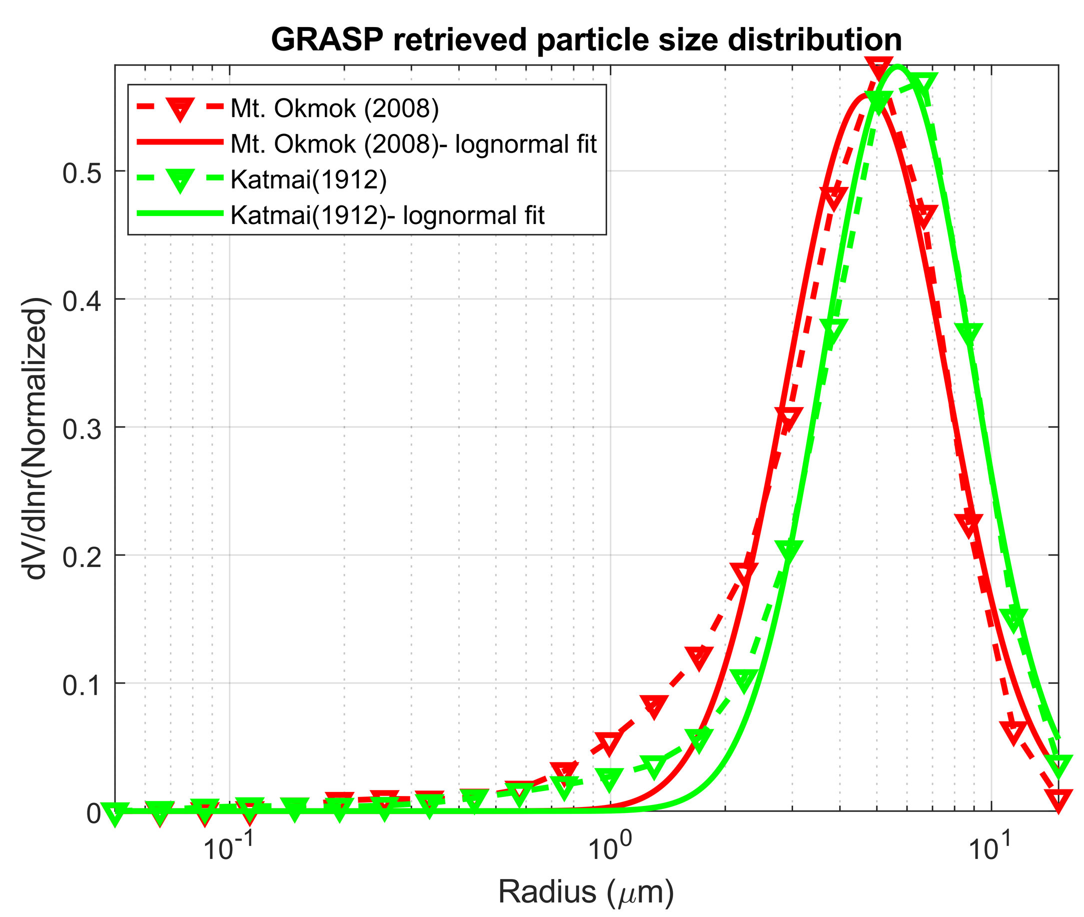

Figure 6: Particle size distribution from retrieved using GRASP(dashed) and lognormal distribution fitted for retrieved PSD(Solid)

Preliminary Observations

- P_{11} of volcanic ashes measured is smooth and featureless
- Highly non-spherical particles
- Minimal spectral dependence in the visible region for P_{11} and $-P_{12}/P_{11}$
- In the near UV wavelengths ash absorption decreases monotonically with wavelength

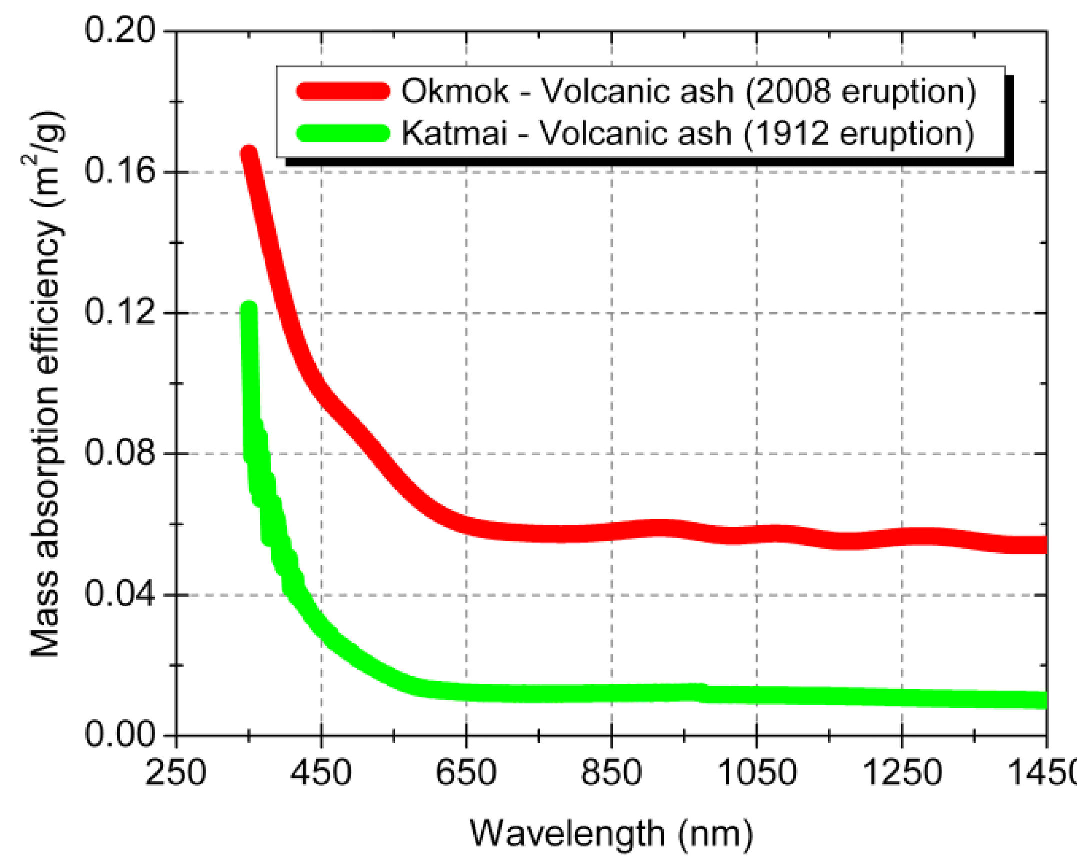

Figure 7: Mass absorption efficiency α_{abs} of the volcanic ash samples measured using a reflectance measurement setup mentioned in technique described by Rocha-lima et. al 2014[5]

Future Research

- Derive particle size and shape distribution using SEM images and ImageJ software
- Measure the chemical composition of ash sample using Energy-dispersive X-ray spectroscopy to find its relationship with microphysical and optical properties of volcanic ash
- Asses the assumptions in satellite retrieval algorithms and improve the accuracy of quantitative estimates of the ash mass loading and other properties using the microphysical and optical properties derived from this study

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