

# Machine Learning techniques applied to cosmological problems.

Martín de los Rios

Director: Dr. Mariano Domínguez

# Resumen

1

Introduction to Machine Learning techniques.

2

The MeSsI (Merging Systems Identification) Algorithm.

3

Derived Results.

- A2029/2033.
- A1204.
- A267.
- Statistical analysis of the magnetic fields in merging clusters.

4

DM- $\gamma$  interactions.

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CosmoML:Machine Learning techniques applied to the CMB.

- Construction of the data set.
- Supervised methods.
- Cosmological parameters Angular distributions.

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Conclusions and Final remarks.

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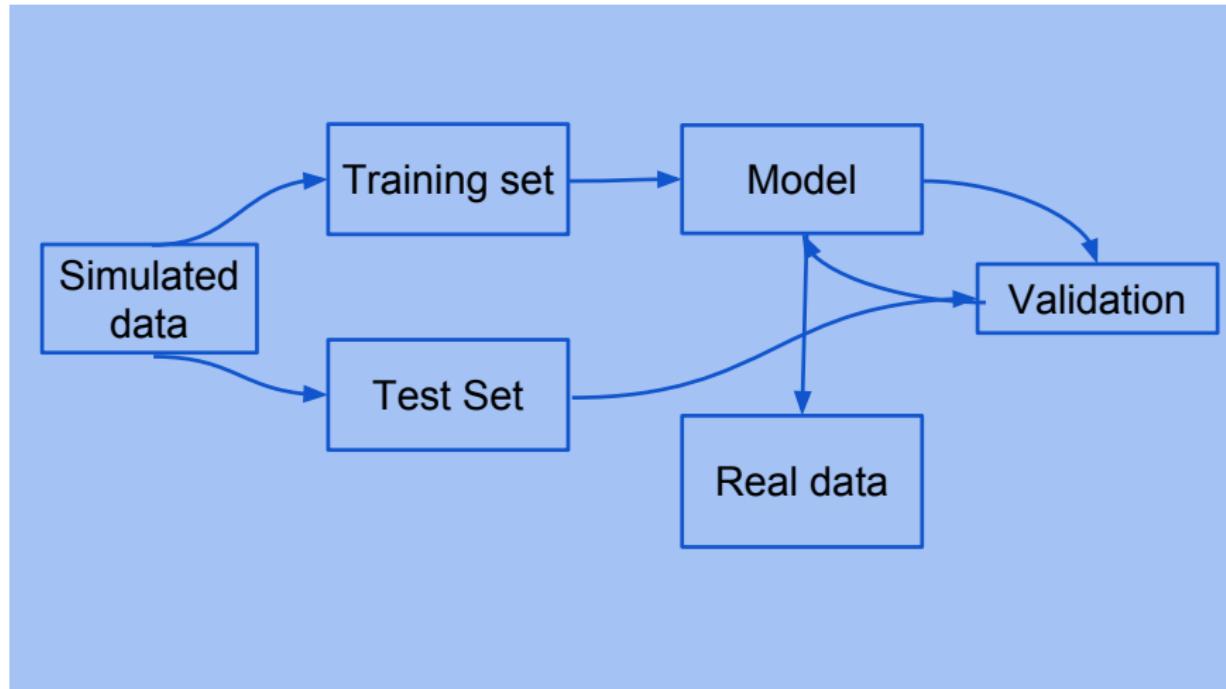
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A computer program learns to perform a task T , based on a training E and taking into account a measure P of its performance, if this measure P when making T improves with the training E.

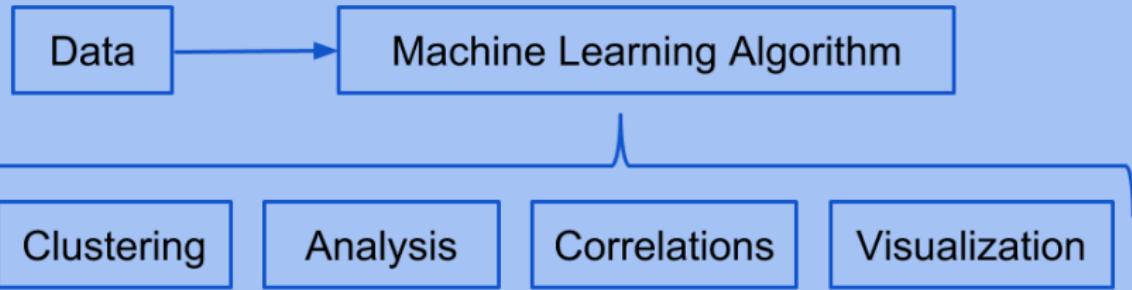
# Supervised Learning.



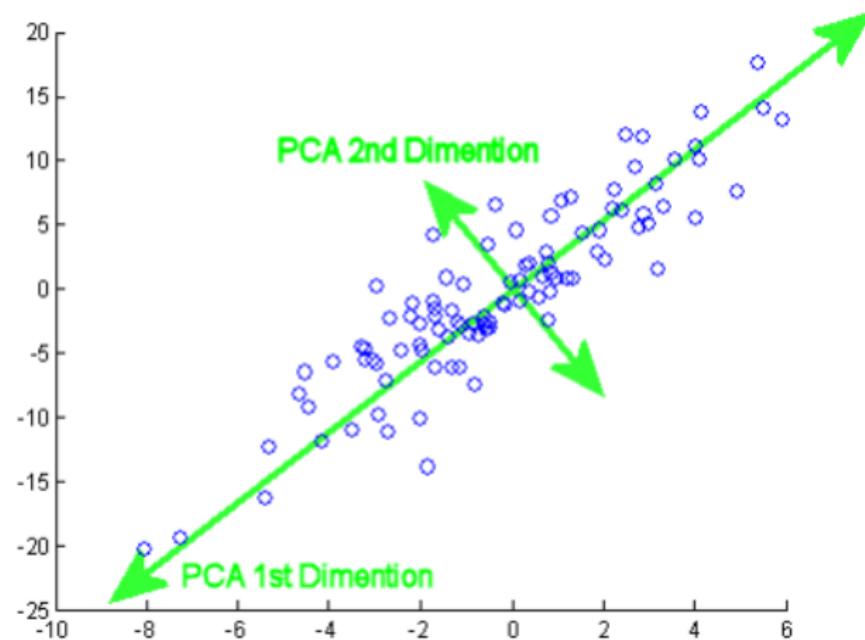
# Random Forest

# Support Vector Machines

# Unsupervised Learning.



# Principal Components Analysis.



# Mixture of Gaussians

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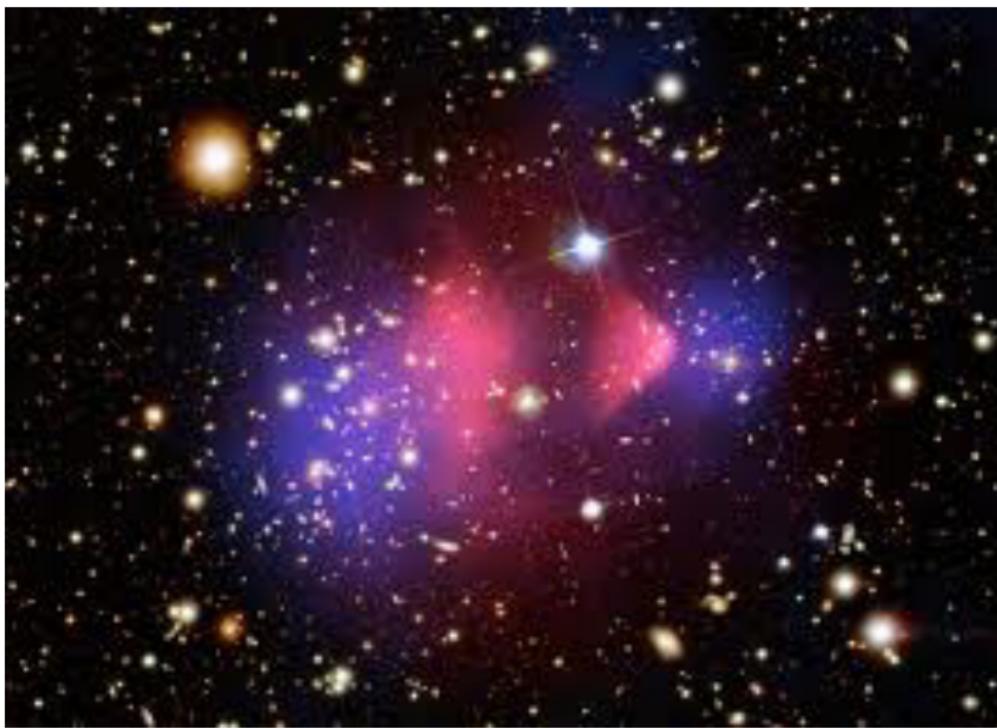
# The MeSSI (Merging Systems Identification) Algorithm & Catalogue.

Martín de los Ríos<sup>1</sup>\*, Mariano J. Domínguez R.<sup>1</sup>\*, Dante Paz, Manuel Merchán<sup>1,2,3</sup>.

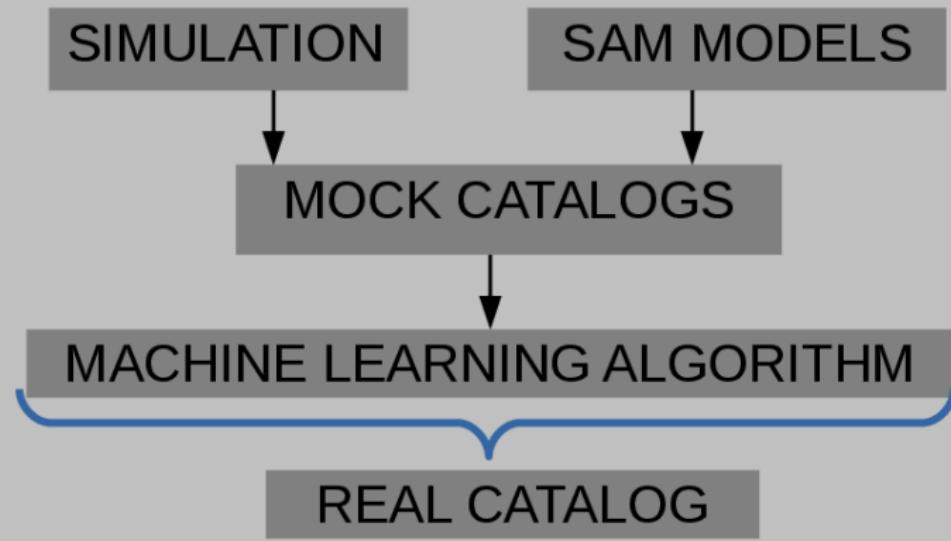
<sup>1</sup> Instituto de Astronomía Teórica y Experimental (CCT Córdoba, CONICET, UNC), Laprida 854, X5000BGR, Córdoba, Argentina.

<sup>2</sup> Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.

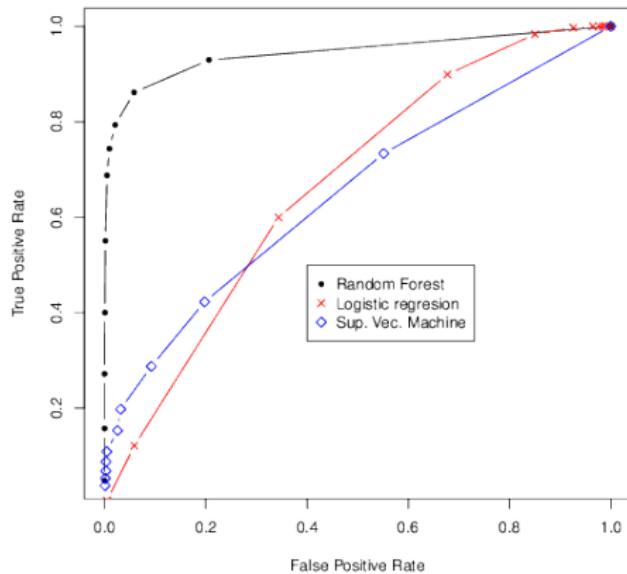
<sup>3</sup> Consejo Nacional de Investigaciones Científicas y Técnicas, Rivadavia 1917, C1033AAJ Buenos Aires, Argentina.



$$\frac{\sigma}{m} < 0.47 \text{ m/s}^2 \text{ (Harvey et al. 2015)}$$



- Dressler-Shectman test.
- Non gaussianity test.
- Color.
- Number of galaxies.



- We found 61 candidates to merging clusters.
- In 32 of these we were able to identify the colliding substructures.
- 21 of these were previously classified as merging clusters by other authors.

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## I. Analysis of candidates for interacting galaxy clusters

### A1204 and A2029/A2033

Elizabeth Johana Gonzalez <sup>1,2</sup>, Martín de los Ríos<sup>1,2</sup>, Gabriel A. Oio<sup>1,2</sup>, Daniel Hernández Lang<sup>4</sup>, Tania Paez Tagliaferro<sup>1,2</sup>, Mariano J. Domínguez R.<sup>1,2</sup>, José Luis Nilo Castellón<sup>3,4</sup>, Héctor Cuevas L.<sup>4</sup>, and Carlos A. Valotto<sup>1,2</sup>

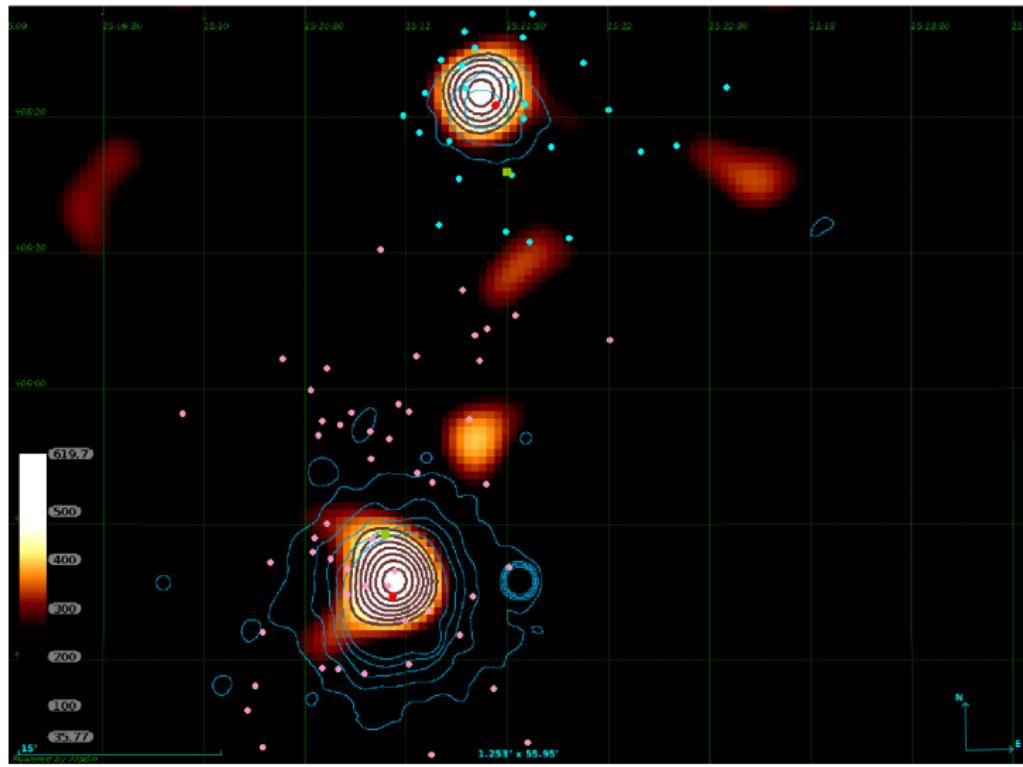
<sup>1</sup> Instituto de Astronomía Teórica y Experimental, (IATE-CONICET), Laprida 854, X5000BGR, Córdoba, Argentina.

<sup>2</sup> Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.

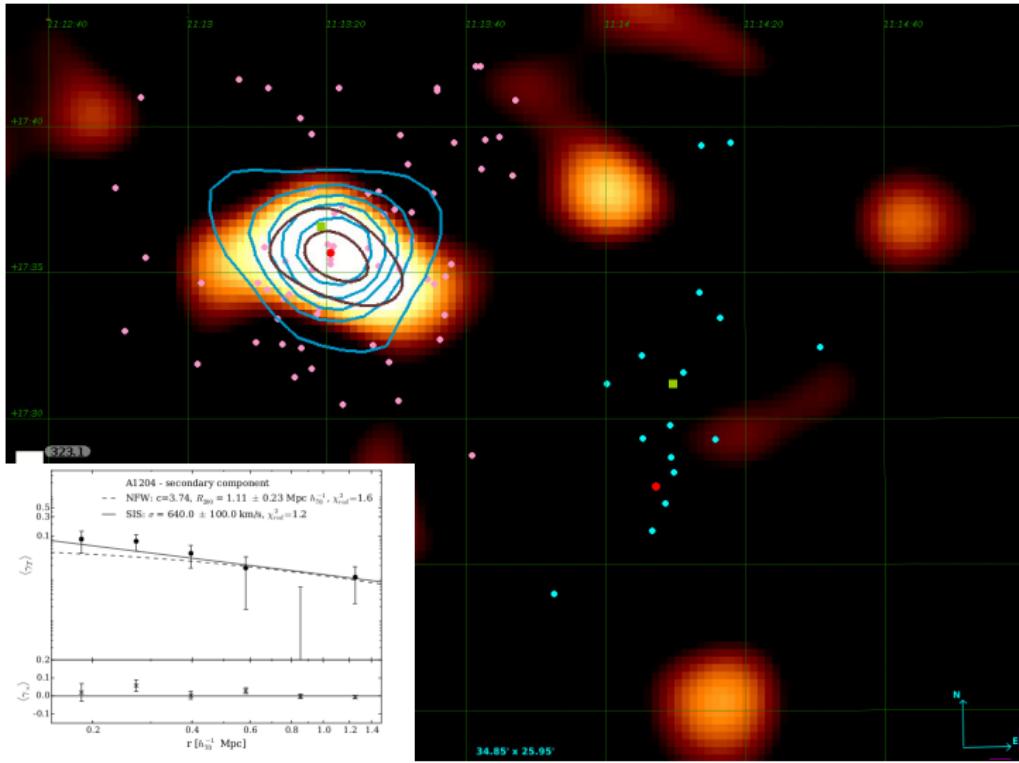
<sup>3</sup> Instituto de Investigación Multidisciplinario en Ciencia y Tecnología, Universidad de La Serena. Benavente 980, La Serena, Chile.

<sup>4</sup> Departamento de Física y Astronomía, Facultad de Ciencias, Universidad de La Serena. Av. Juan Cisternas 1200, La Serena, Chile.

# A2029/2033



# A1204



## **II. Analysis of candidates for interacting galaxy clusters: A267, a merging fossil group.**

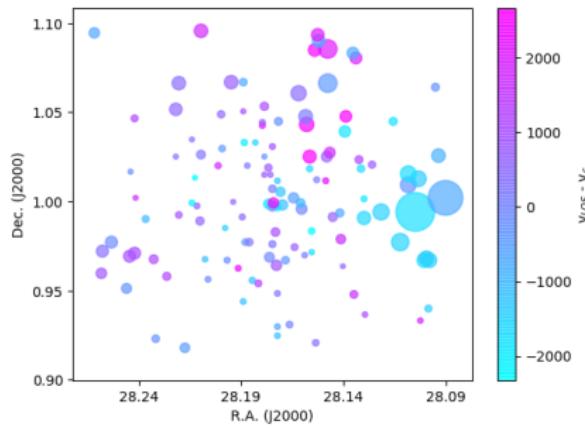
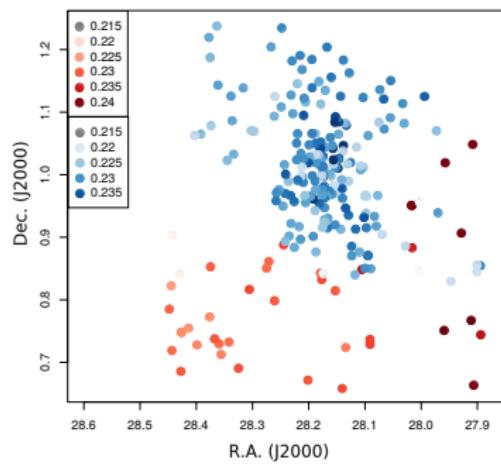
Elizabeth Johana Gonzalez <sup>★1,2</sup>, María Jose Kanagusuku<sup>1,2</sup>, Martín de los Rios<sup>1,2</sup>, Gabriel A. Oio<sup>1,2</sup>, Daniel Hernández Lang<sup>4</sup>, Tania Aguirre Tagliaferro<sup>1,2</sup>, Mariano J. Domínguez R.<sup>1,2</sup>, José Luis Nilo Castellón<sup>3,4</sup>, Héctor Cuevas L.<sup>4</sup>, and Carlos A. Valotto<sup>1,2</sup>

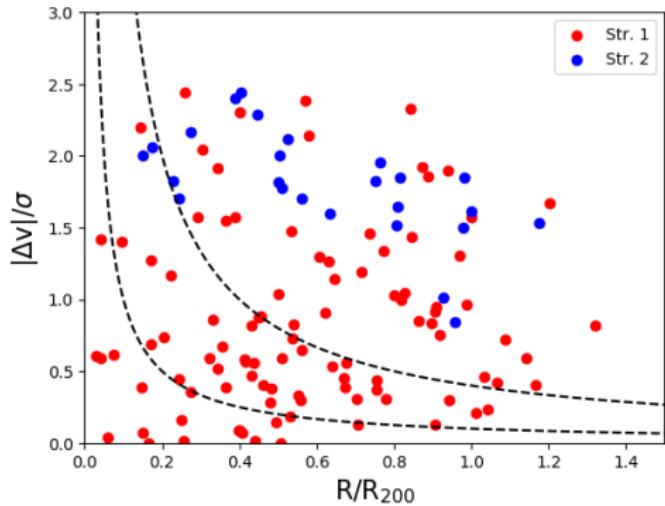
<sup>1</sup> Instituto de Astronomía Teórica y Experimental, (IATE-CONICET), Laprida 854, X5000BGR, Córdoba, Argentina.

<sup>2</sup> Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.

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- $\approx 40\%$  Fossil groups have a major merger  $z < 0.8$ .
- $\approx 15 - 25\%$  Fossil groups have a major merger  $z < 0.3$ .

Noble et al. 2013

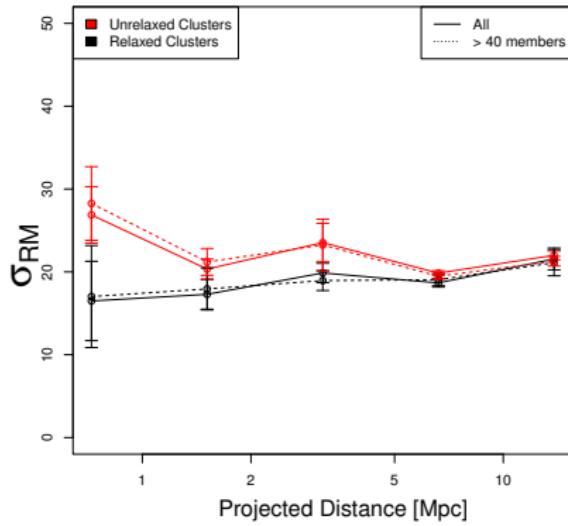
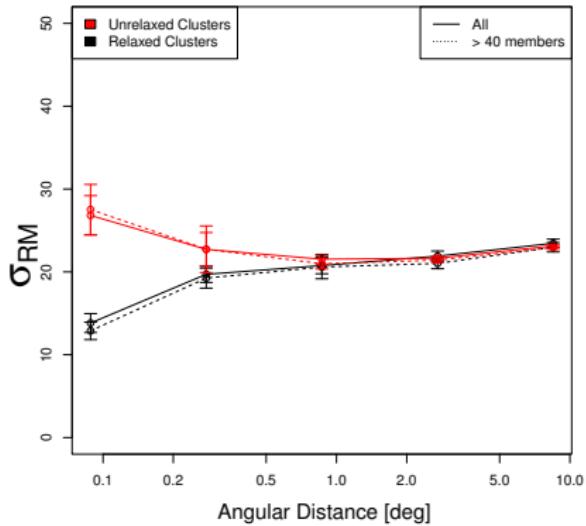
# Faraday Rotation Measure dependence with galaxy clusters dynamics

F.A. Stasyszyn<sup>1,2\*</sup> & M. de los Rios<sup>1,2,3</sup>

<sup>1</sup> Instituto de Astrofísica Teórica y Experimental (IATE), Laprida 854, Córdoba, Argentina

<sup>2</sup> Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.

<sup>3</sup> Consejo Nacional de Investigaciones Científicas y Técnicas, Rivadavia 1917, C1033AAJ Buenos Aires, Argentina.



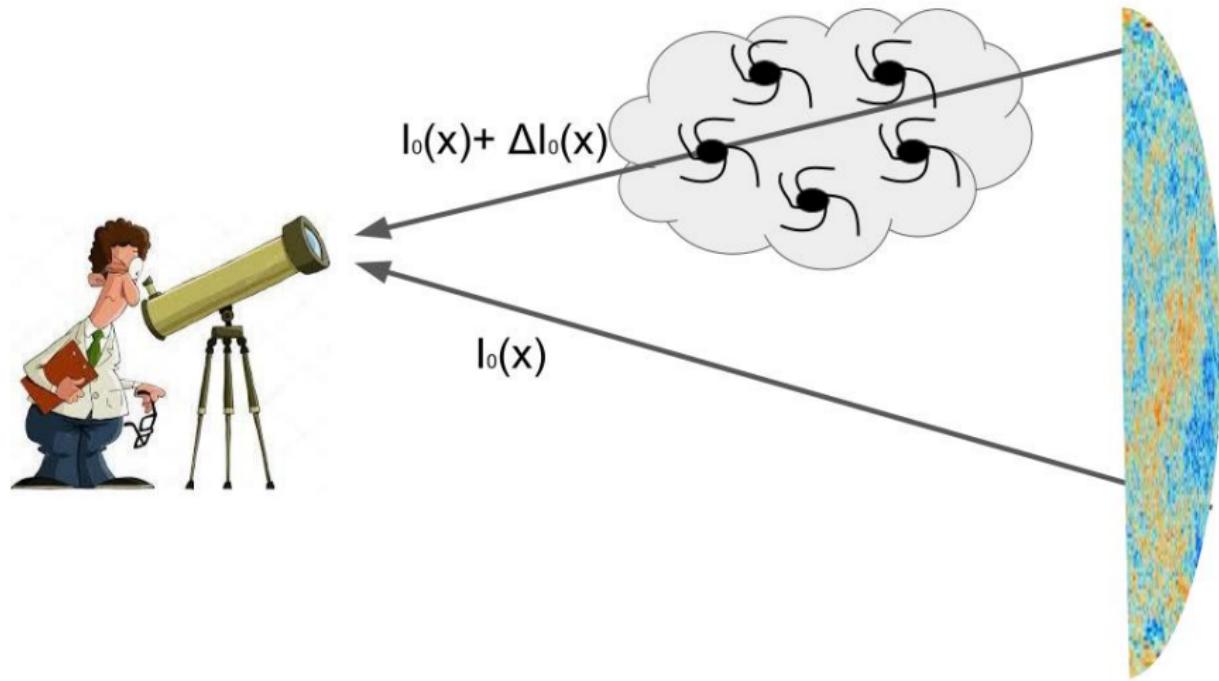
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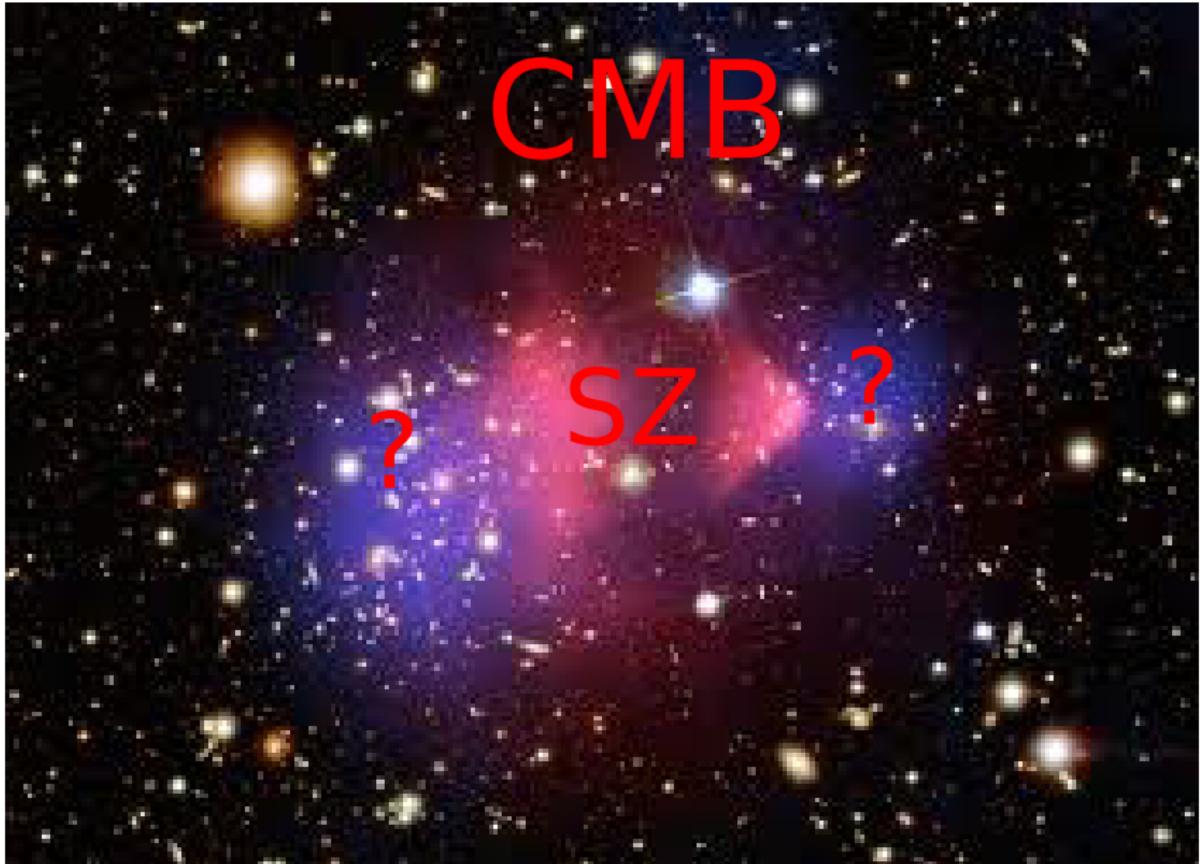
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# DM- $\gamma$ interactions (work in progress)

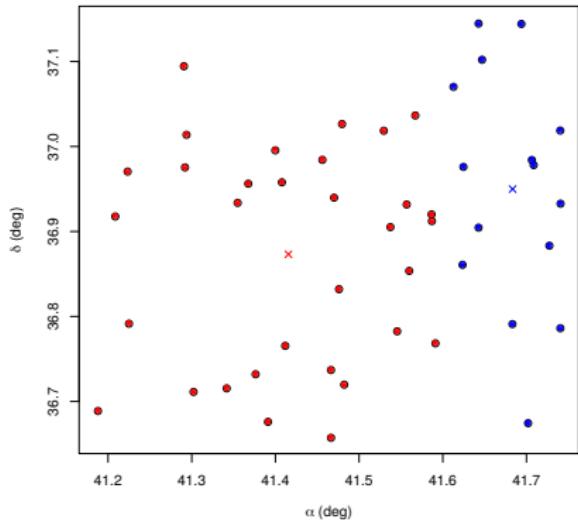
In collaboration with Dra. Celine Böhm



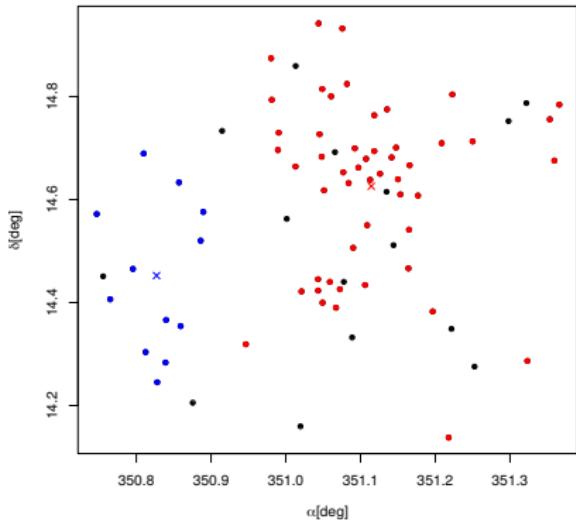


# Future work

A376



A2593



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# **CosmoML: Machine Learning techniques applied to the Cosmic Microwave Background.**

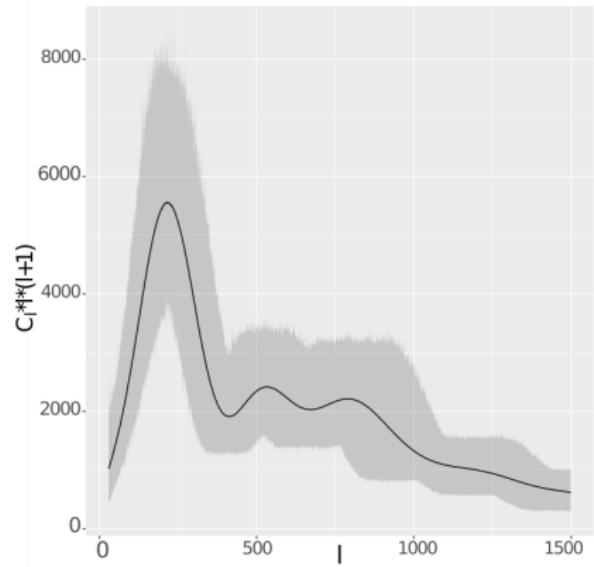
Martín de los Ríos<sup>★</sup>, Mariano J. Domínguez R.<sup>★ 1,2,3</sup>.

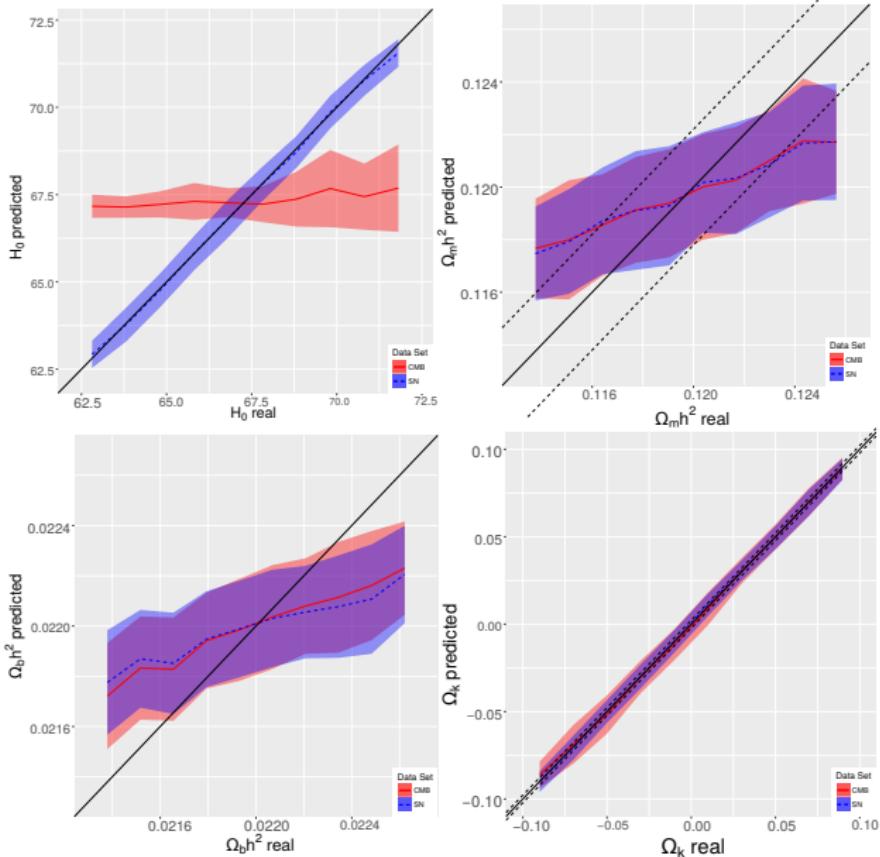
<sup>1</sup> Instituto de Astronomía Teórica y Experimental (CCT Córdoba, CON ICET, UNC), Laprida 854, X5000BGR, Córdoba, Argentina.

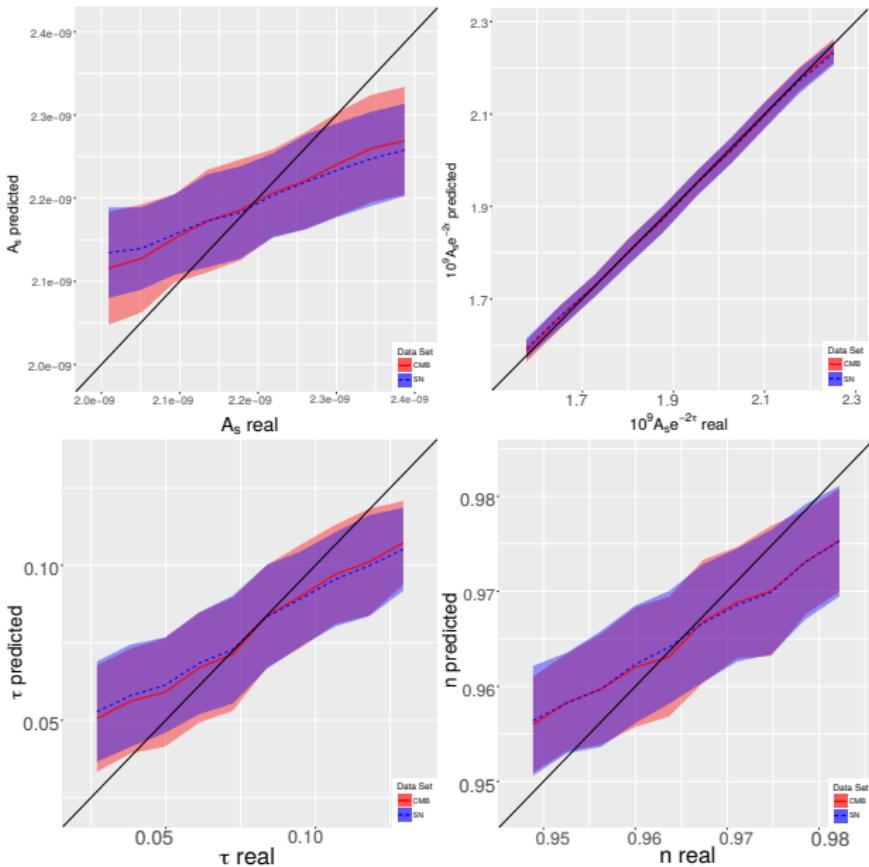
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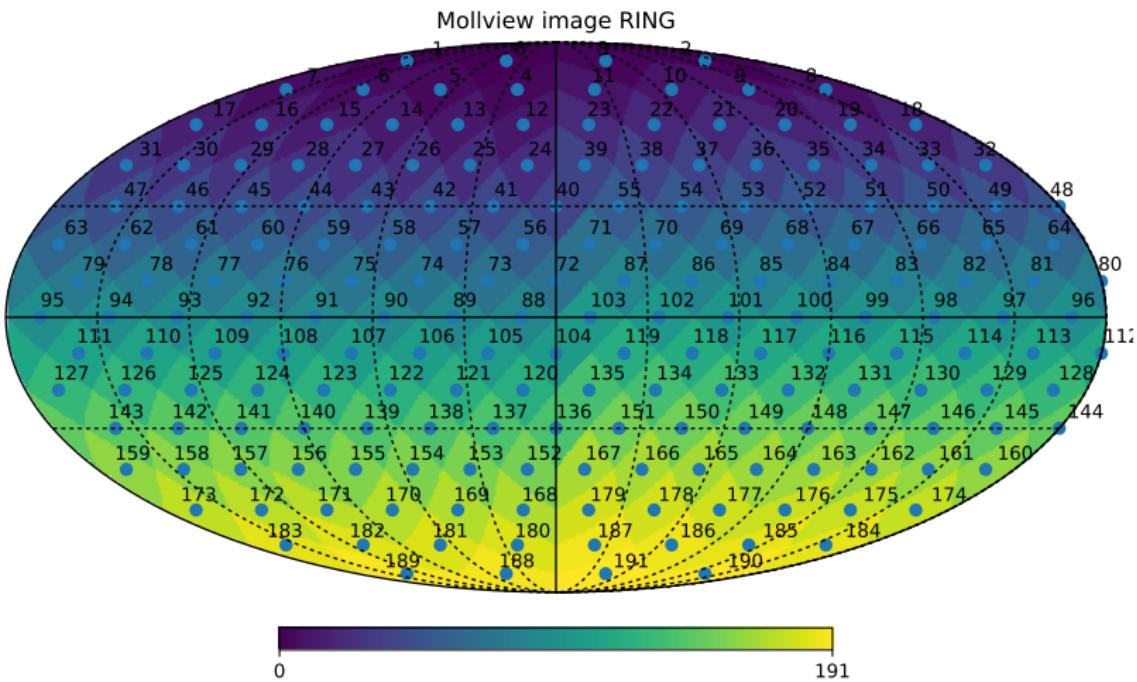
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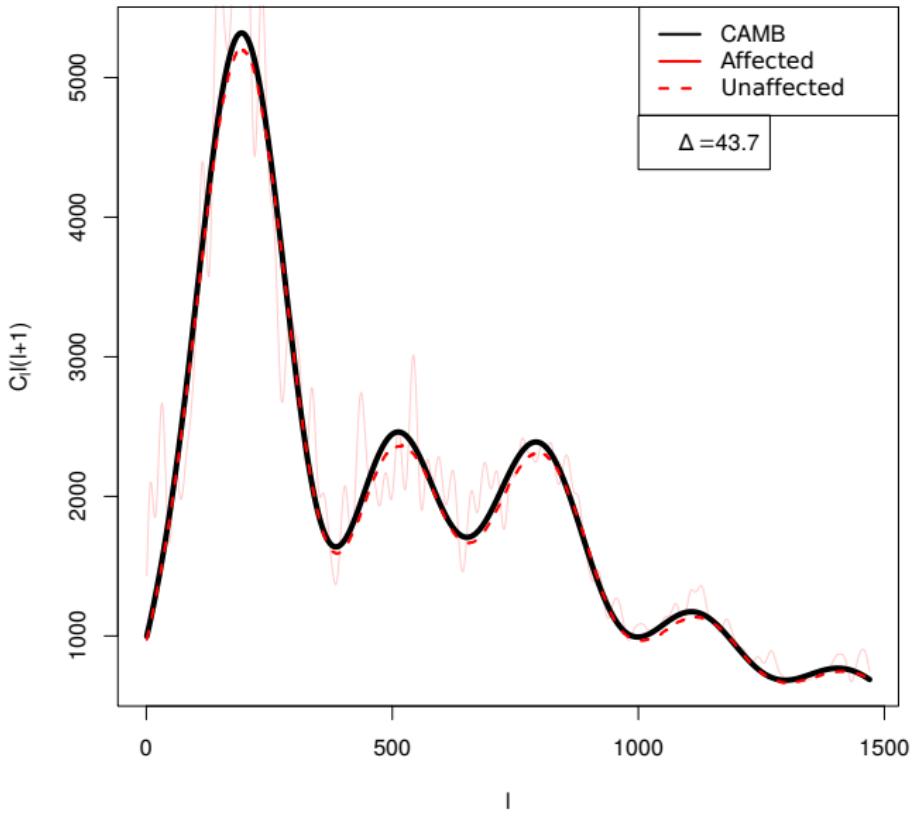
Parameter	Minimum	Maximum	Planck
$\Omega_m h^2$	0.1131	0.1263	0.1197
$\Omega_b h^2$	0.02131	0.02269	0.022
$\Omega_k$	-0.1	0.1	0
$H_0$	62.31	72.31	67.31
$n$	0.9469	0.9841	0.9655
$A_s$	$1.988 * 10^{-9}$	$2.408 * 10^{-9}$	$2.198 * 10^{-9}$
$\tau$	0.021	0.1349	0.078

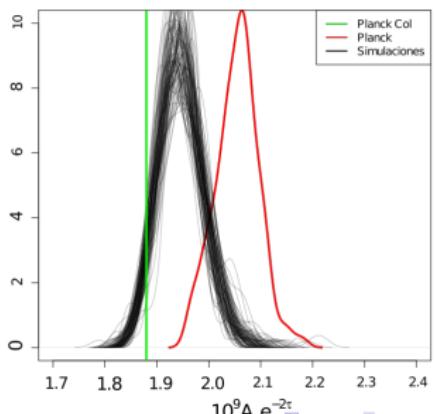
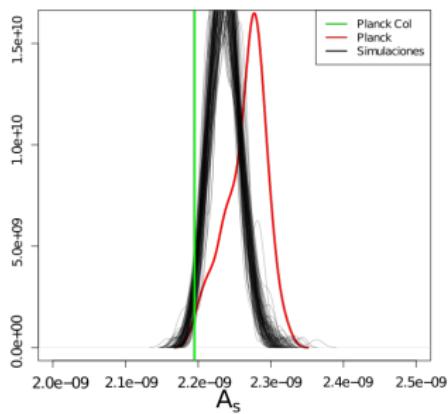
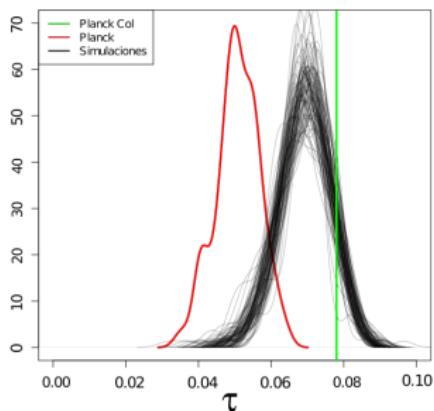
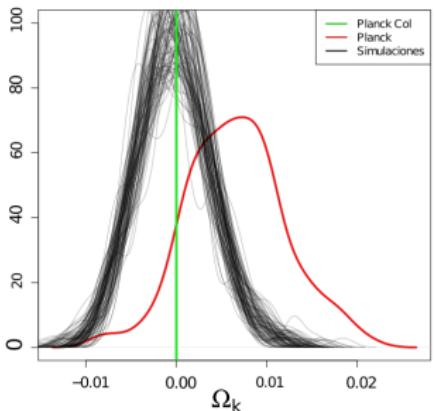












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- We studied the cosmic microwave background using Machine Learning techniques.
- We studied the angular distributions of the cosmological parameters without finding anything unexpected in the standard cosmological model, with the possible exception of the parameter  $10^9 A_s e^{-2\tau}$ .

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- They can be very useful for classification and regression problems, achieving, in most of the problems, better results than the traditional methods in lower computational time.
- Taking into account the large amount of data that will be recorded by the future surveys, this technique will be essential for their analysis.



# THANK YOU