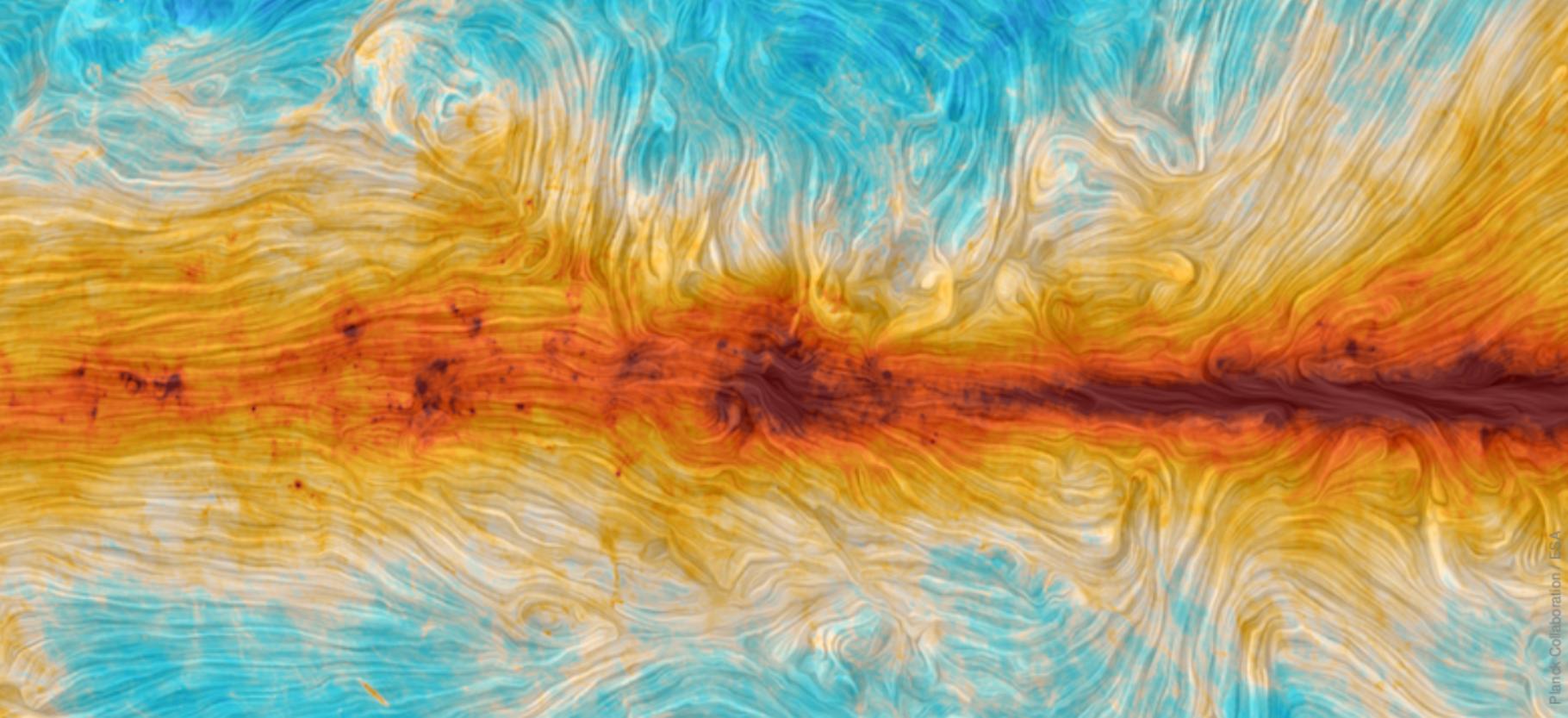


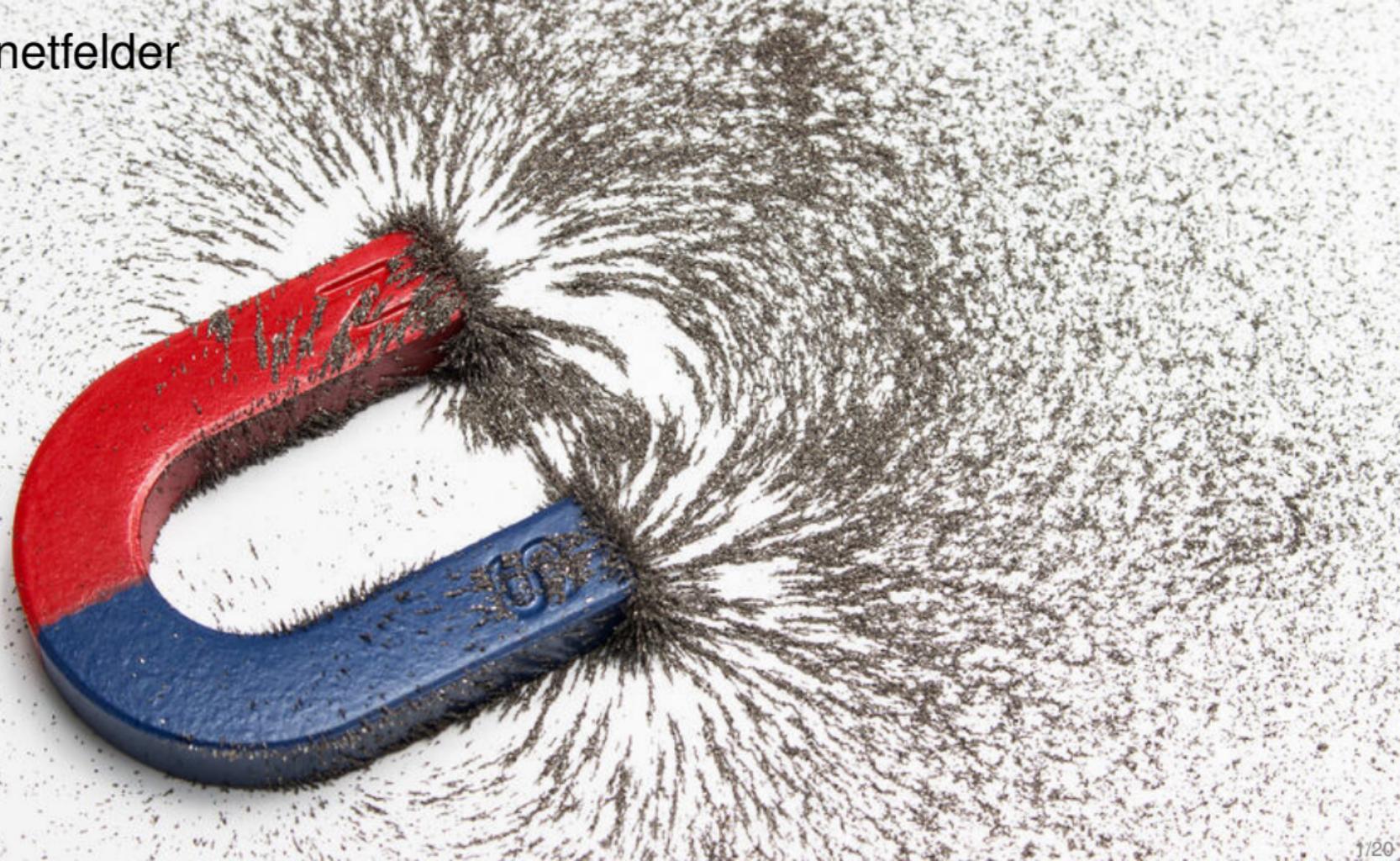
Astroteilchen in kosmischen Magnetfeldern

Michael Unger (IAP, KIT)

"Unser Universum" – KCETA im Naturkundemuseum Karlsruhe, 23.11.2025



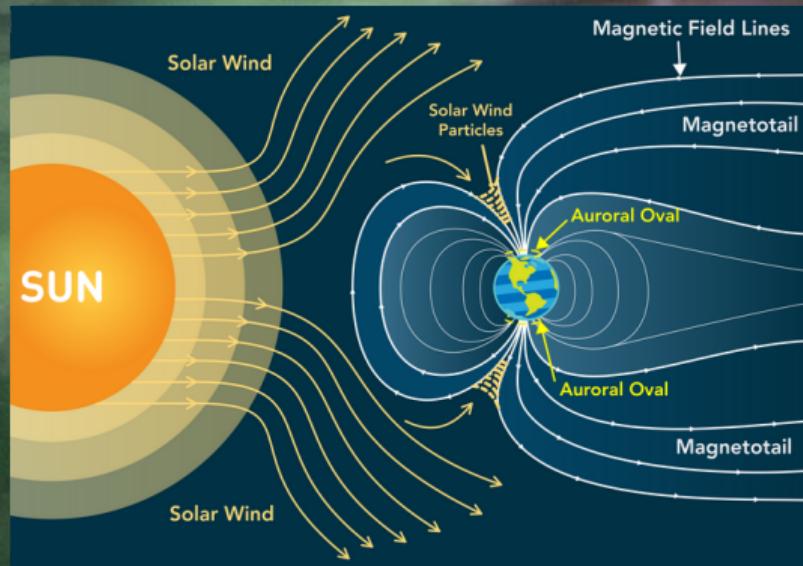
Magnetfelder



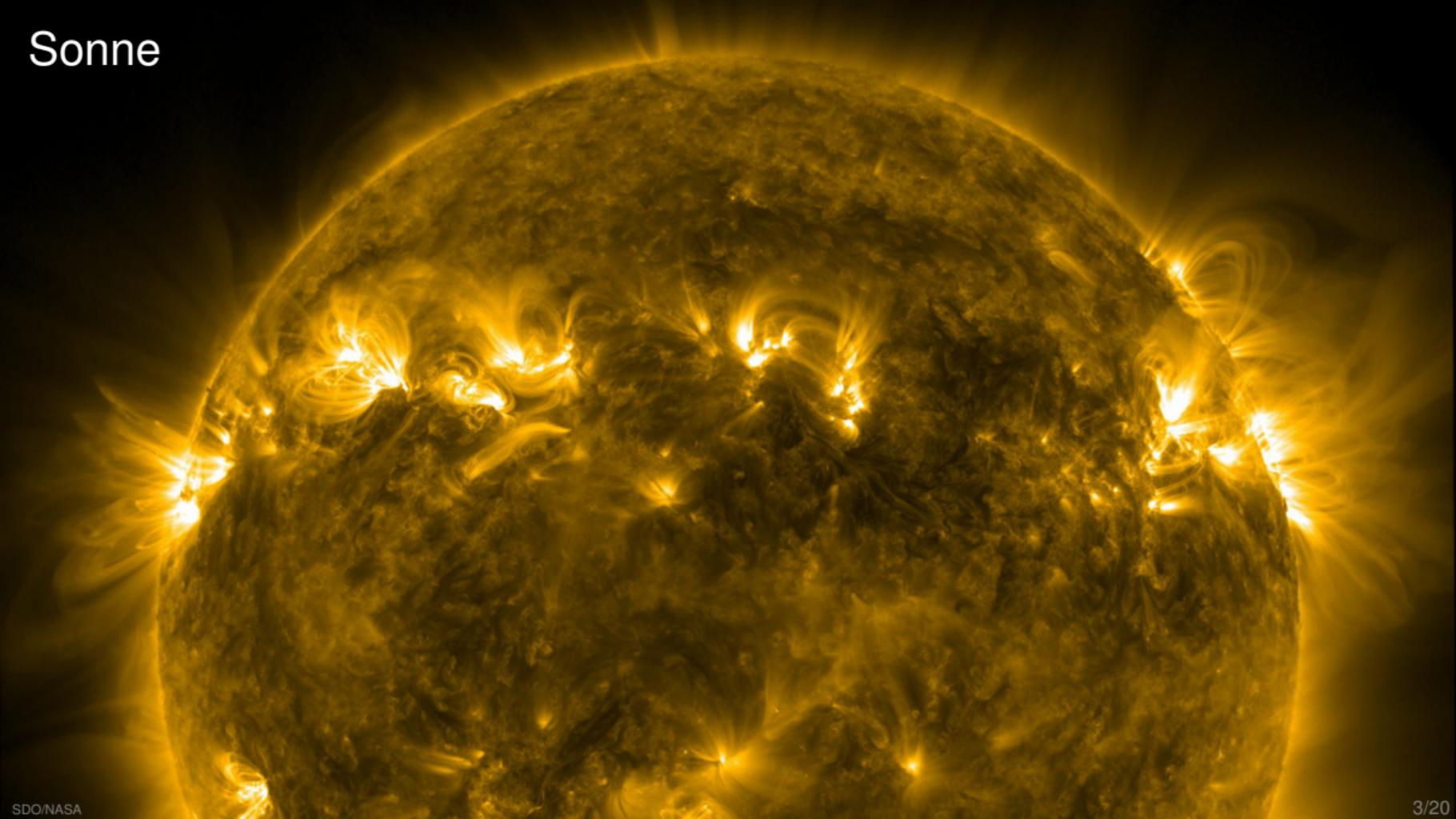
Erde



Erde



Sonne



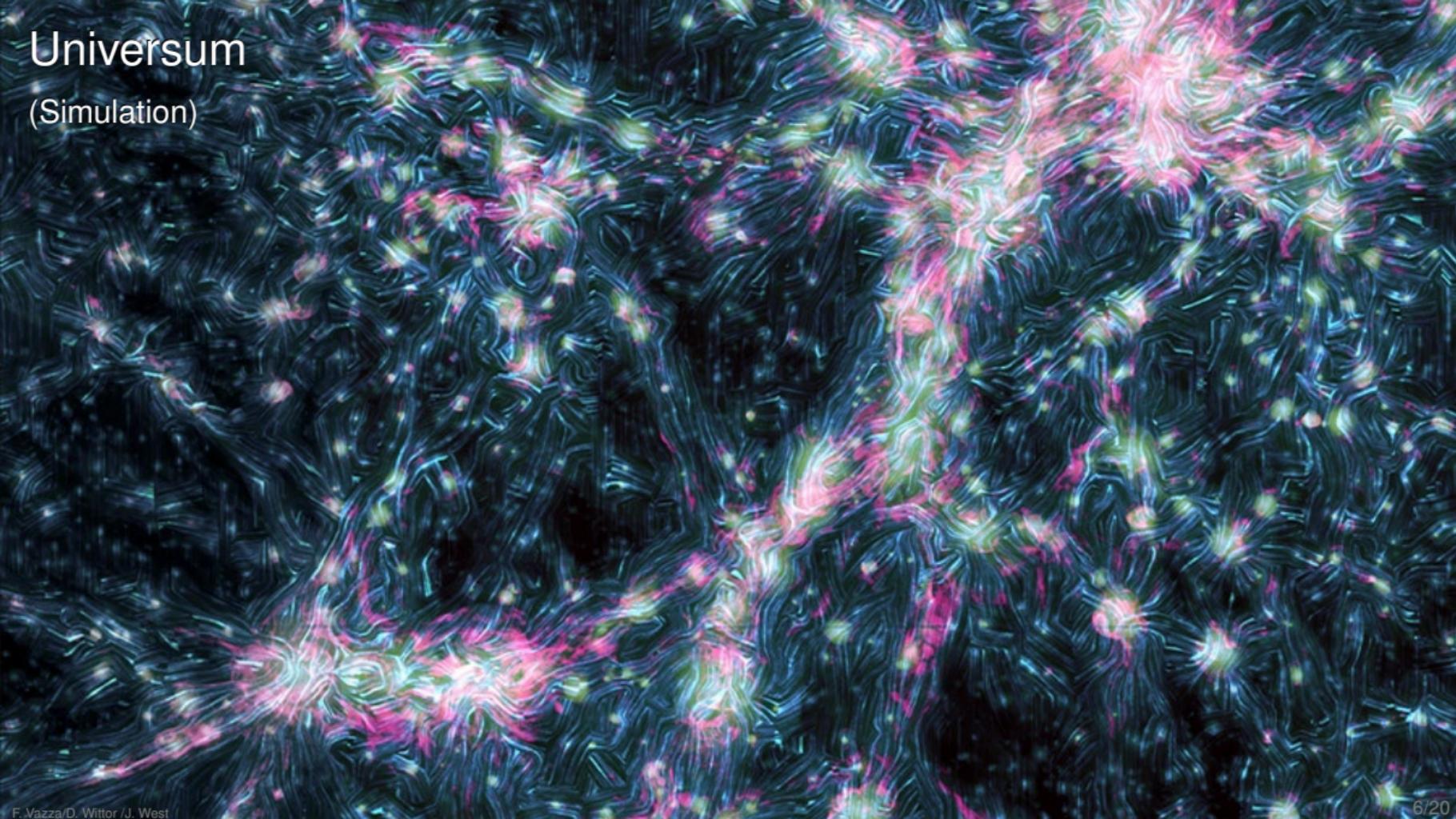
Galaktisches Zentrum – innerste 1000 Lj (Entfernung 26 000 Lj)



Galaxien



Universum (Simulation)



Entstehung kosmischer Magnetfelder: Dynamo

- Dynamo am Fahrrad: Bewegung → Licht

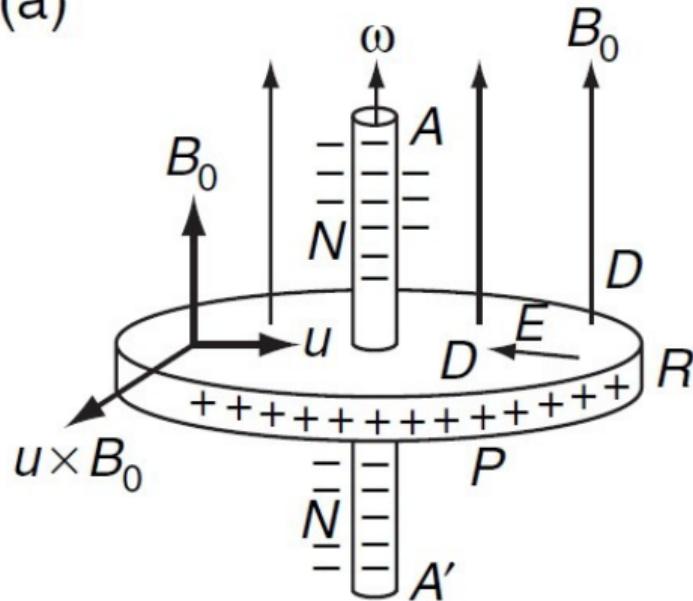


- Astrophysikalischer Dynamo: Bewegung → Magnetfeld!

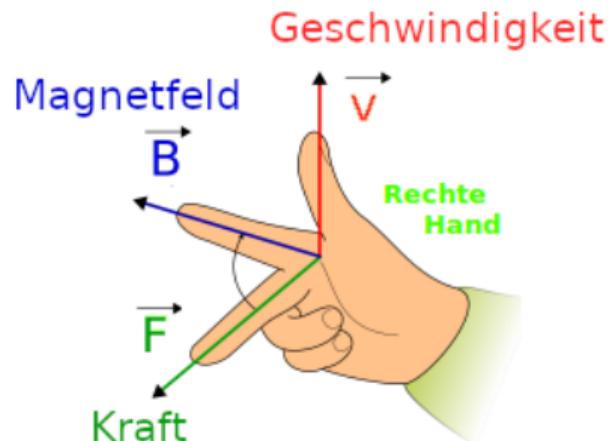
Entstehung kosmischer Magnetfelder: Dynamo

Beispiel: Rotierende Metallscheibe im Anfangsmagnetfeld B_0

(a)



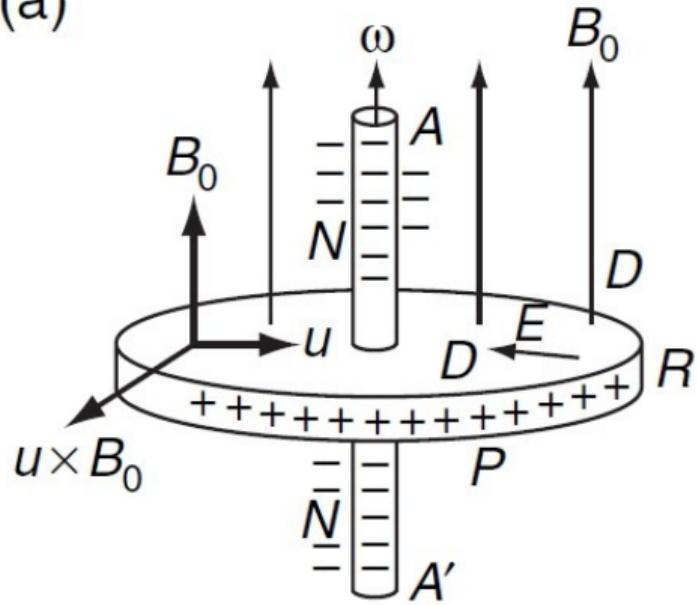
Drei-Finger-Regel



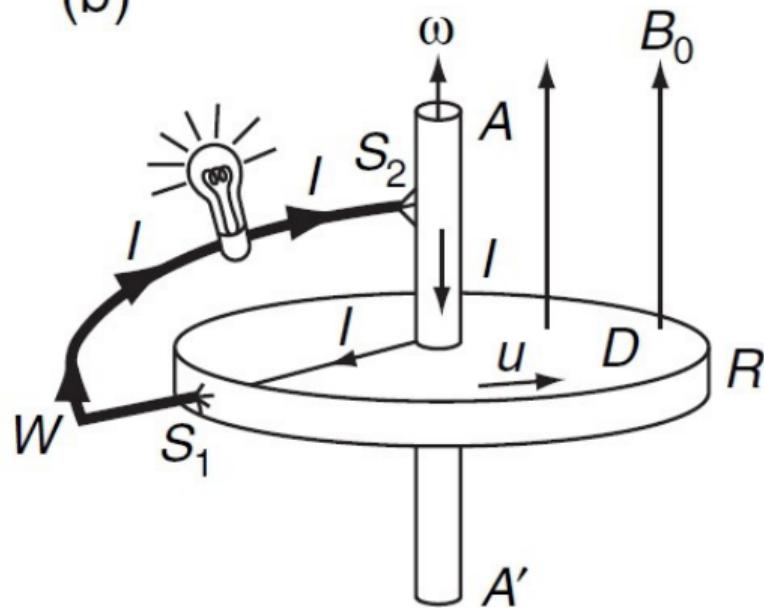
Entstehung kosmischer Magnetfelder: Dynamo

Beispiel: Rotierende Metallscheibe im Anfangsmagnetfeld B_0

(a)

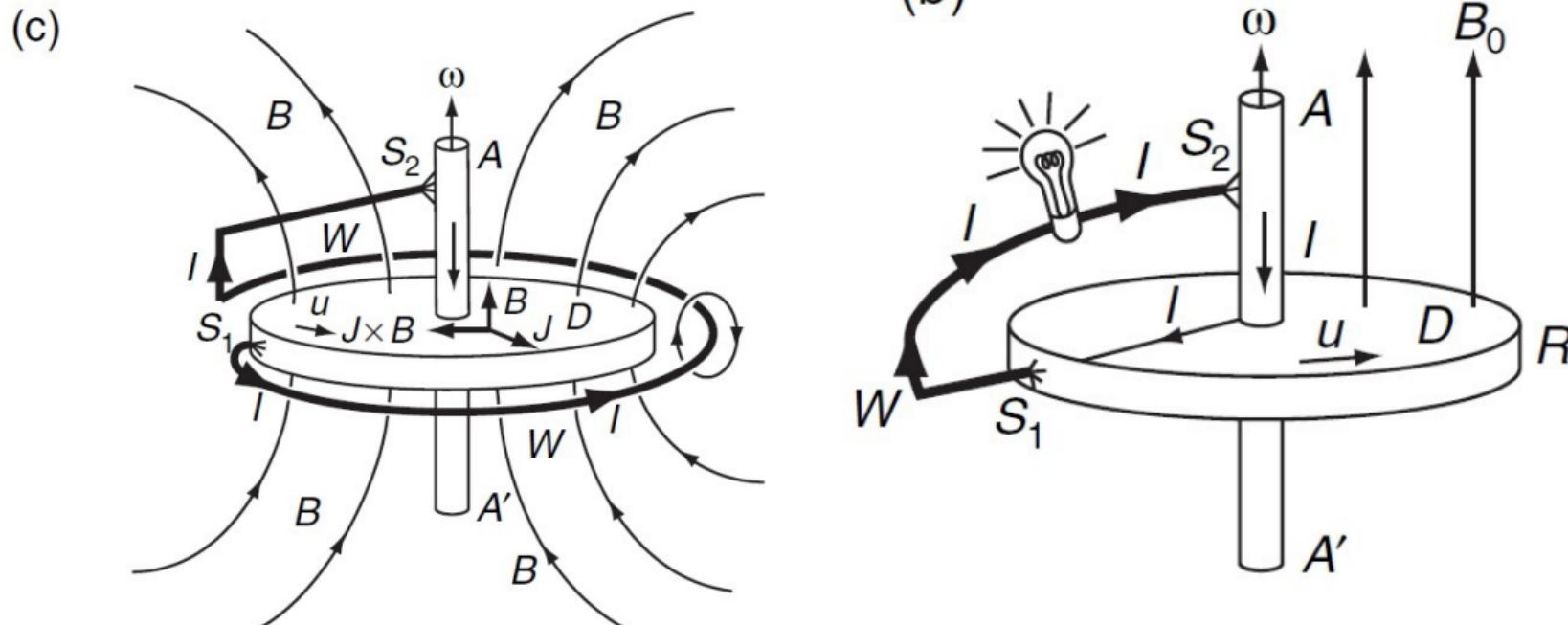


(b)



Entstehung kosmischer Magnetfelder: Dynamo

Beispiel: Rotierende Metallscheibe im Anfangsmagnetfeld B_0



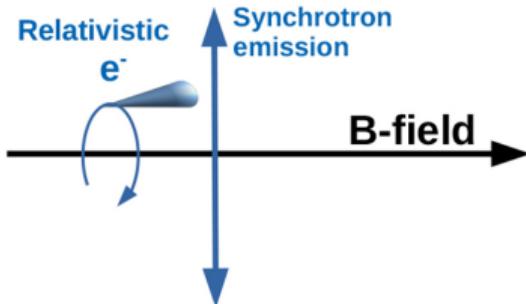
Verstärkung des Anfangsmagnetfeldes, $B > B_0$!

Beobachtung von astrophysikalischen Magnetfeldern

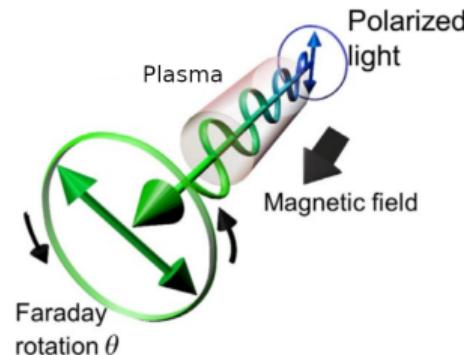


Beobachtung von astrophysikalischen Magnetfeldern

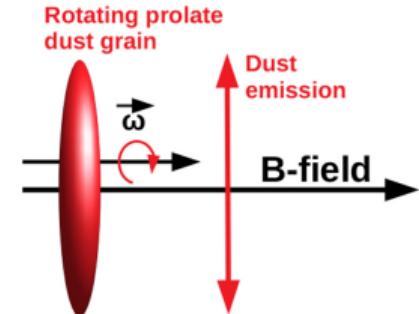
Synchrotronstrahlung



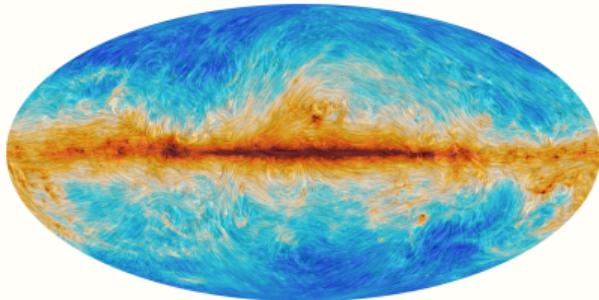
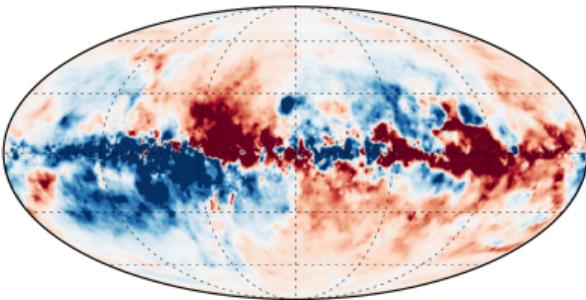
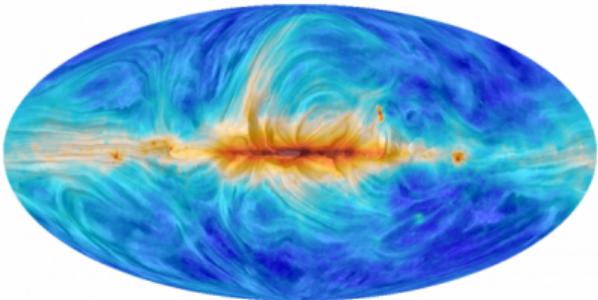
Faraday Rotation



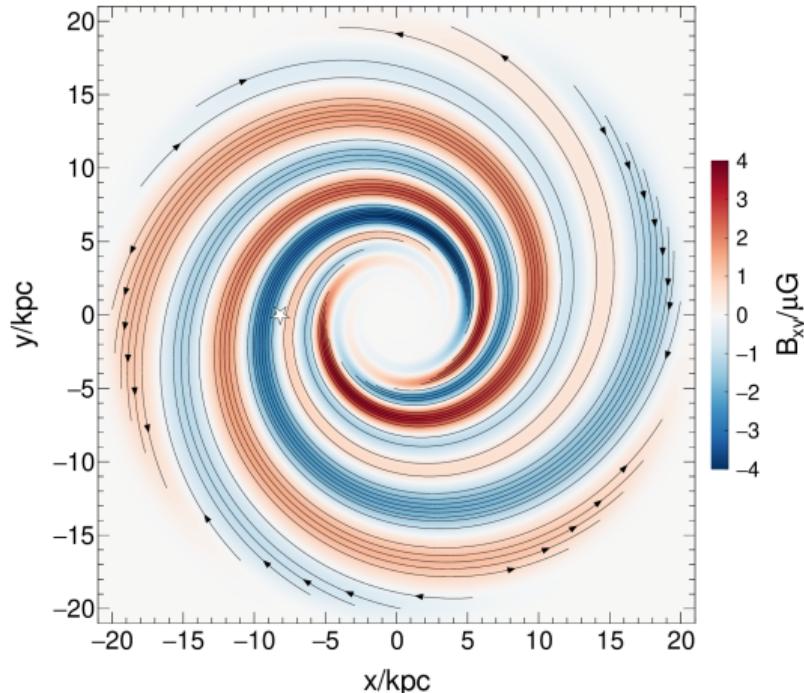
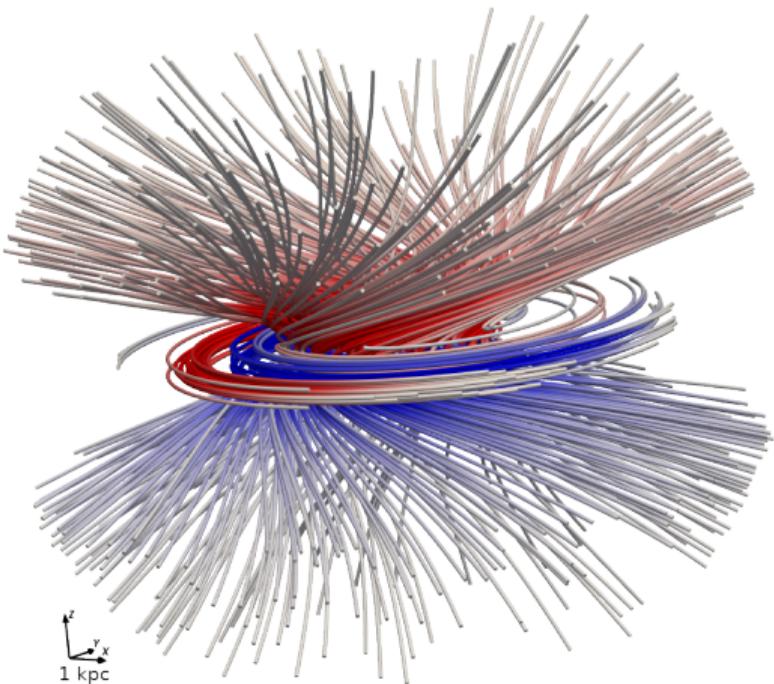
Polarisierte Staubemission



Himmelskarten:



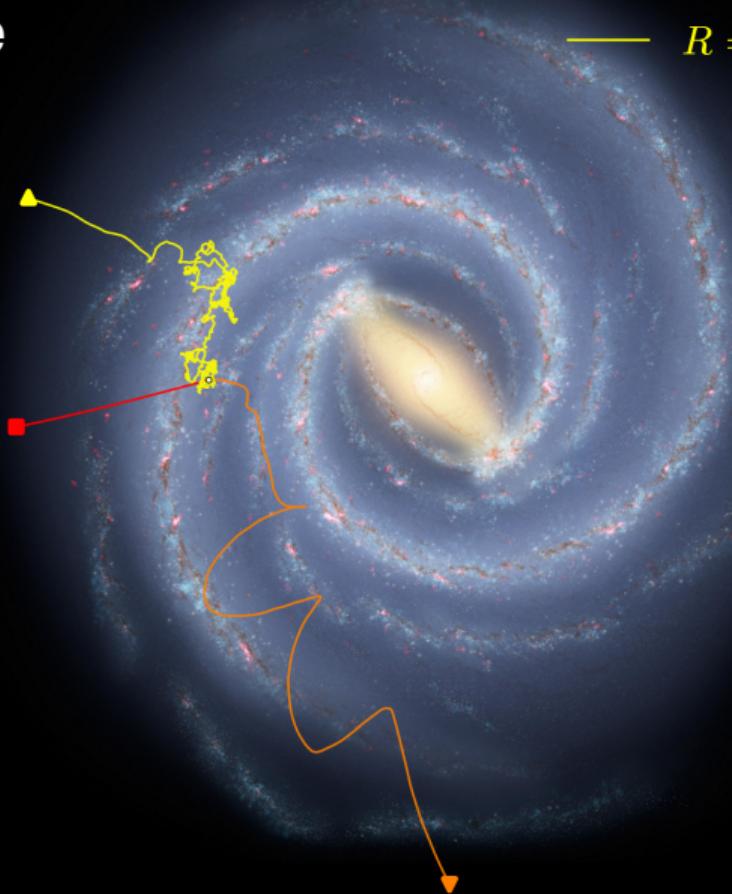
Modell des Magnetfeldes der Milchstraße



Anpassung der Modellparameter → Beschreibung der Himmelkarten von Synchrotron & Faraday Rotation

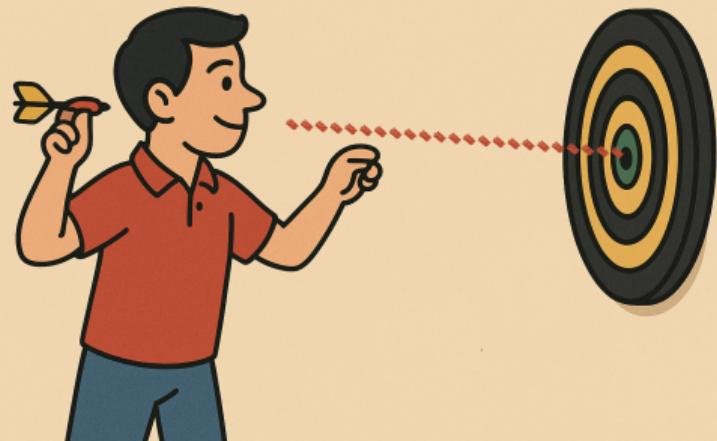
Geladene Teilchen im Magnetfeld der Milchstraße

— $R = 10 \text{ EV}$
— $R = 1.0 \text{ EV}$
— $R = 0.1 \text{ EV}$

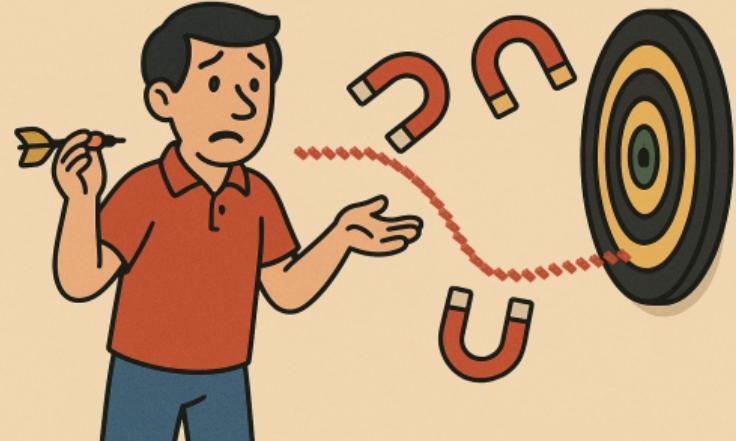


Geladene Teilchen im Magnetfeld der Milchstraße

BALLISTIC PROPAGATION

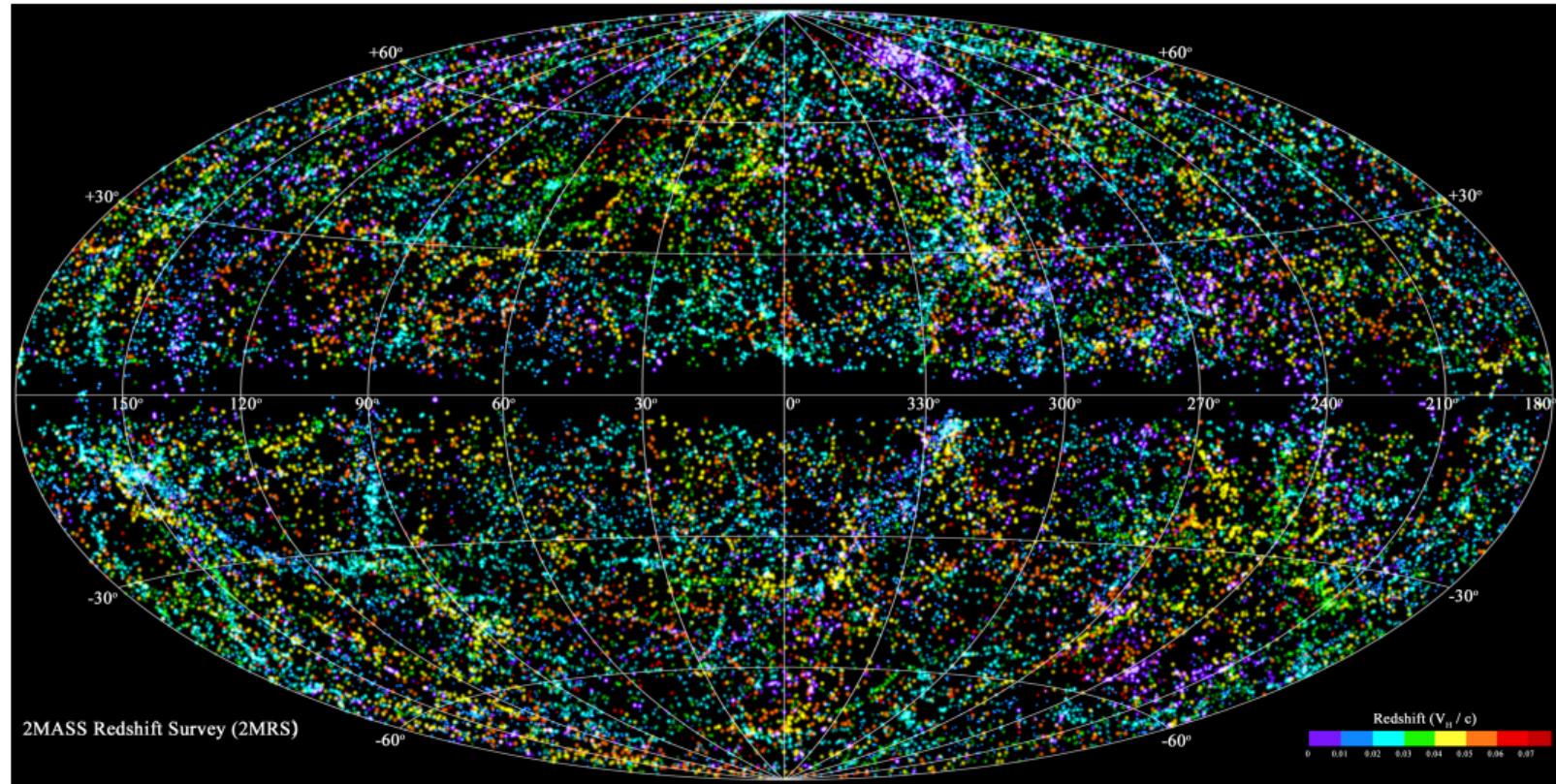


DEFLECTION



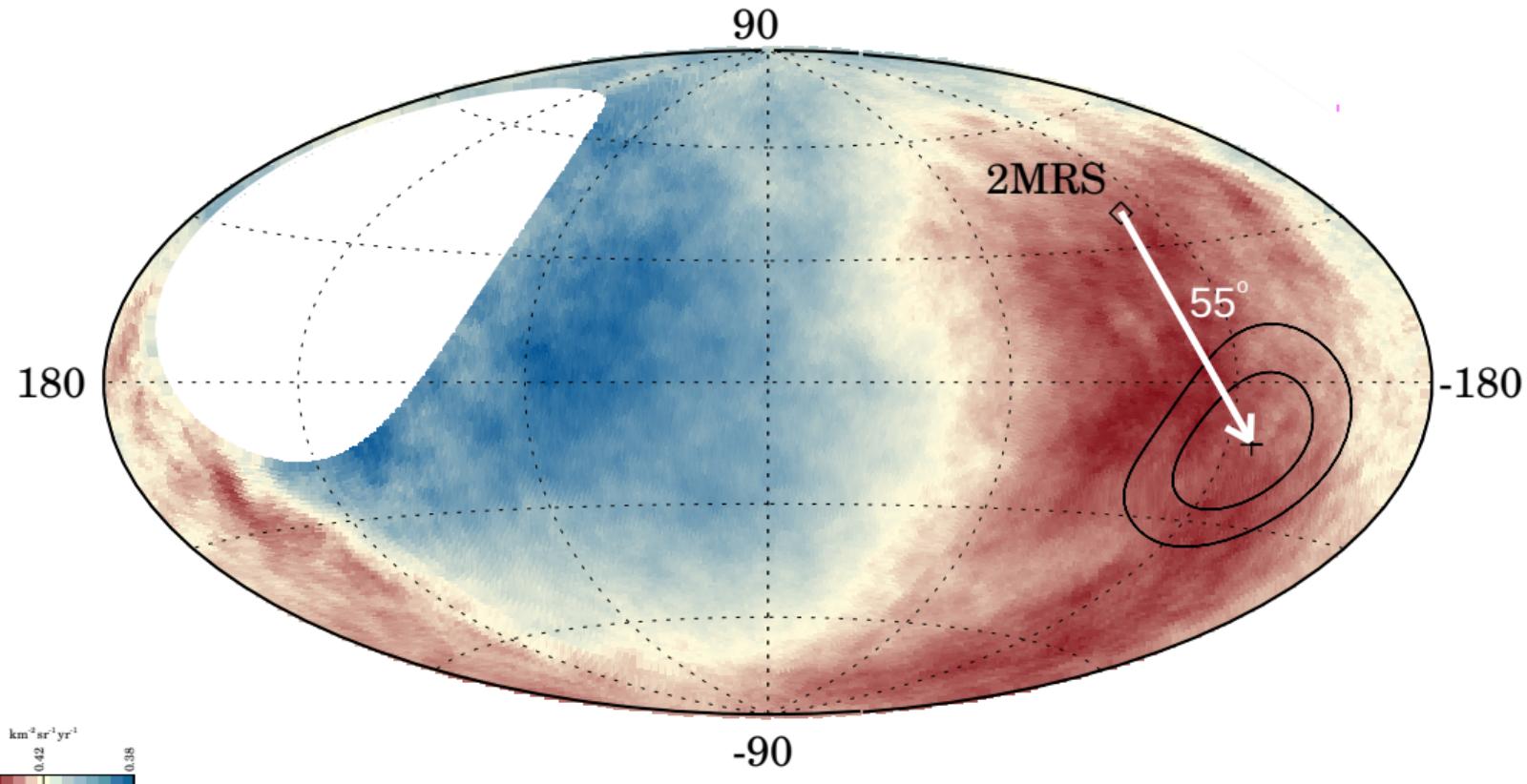
Das Modell auf dem Prüfstand: Ankunftsrichtungen kosmischer Strahlen

Galaxien in der kosmischen Nachbarschaft:



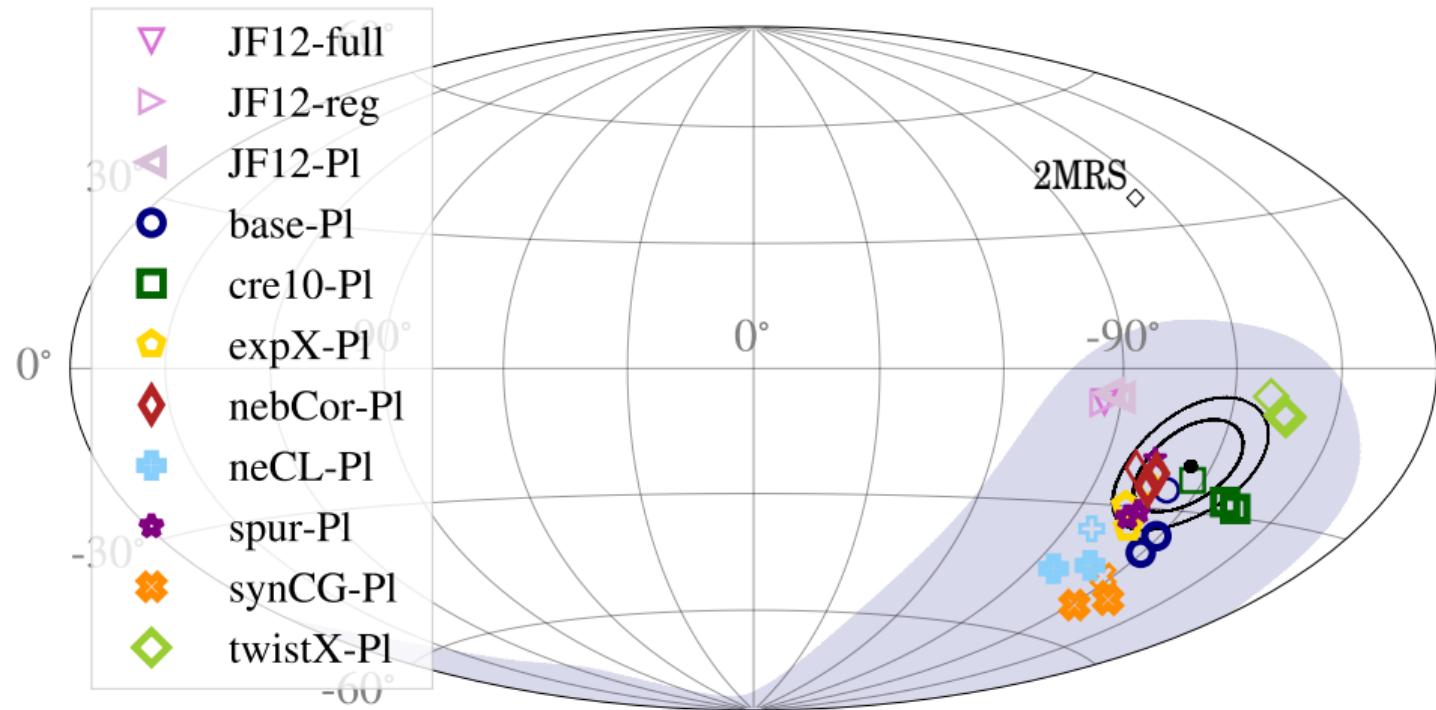
Das Modell auf dem Prüfstand: Ankunftsrichtungen kosmischer Strahlen

Himmelskarte der kosmischen Strahlen (siehe Vortrag von Markus Roth):



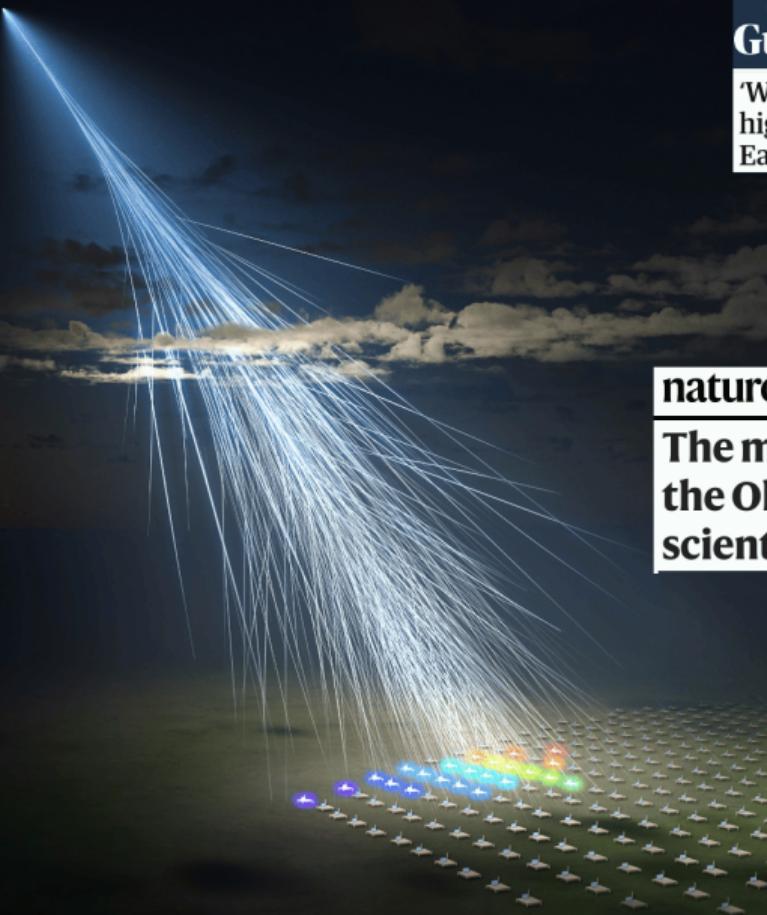
Das Modell auf dem Prüfstand: Ankunftsrichtungen kosmischer Strahlen

Modellvorhersagen inkl. Magnetfeld der Milchstraße



Modelle reproduzieren beobachtete Dipol-Ablenkung!

“Amaterasu” Teilchen (27. Mai 2021)



The
Guardian

‘What the heck is going on?’ Extremely high-energy particle detected falling to Earth

SPIEGEL Wissenschaft

Ultrahochenergetisches kosmisches Teilchen traf die Erde

OMG! Schon wieder!

nature

The most powerful cosmic ray since the Oh-My-God particle puzzles scientists

VICE

A Ray From Space Hit Earth with Such Incredible Power That Scientists Named It After a God

The source of the Amaterasu particle, named after the Japanese sun goddess, is a "big mystery."

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Energie pro Teilchen:

Sonnenoberfläche

1 eV

Röhrenröhre

12,000 eV

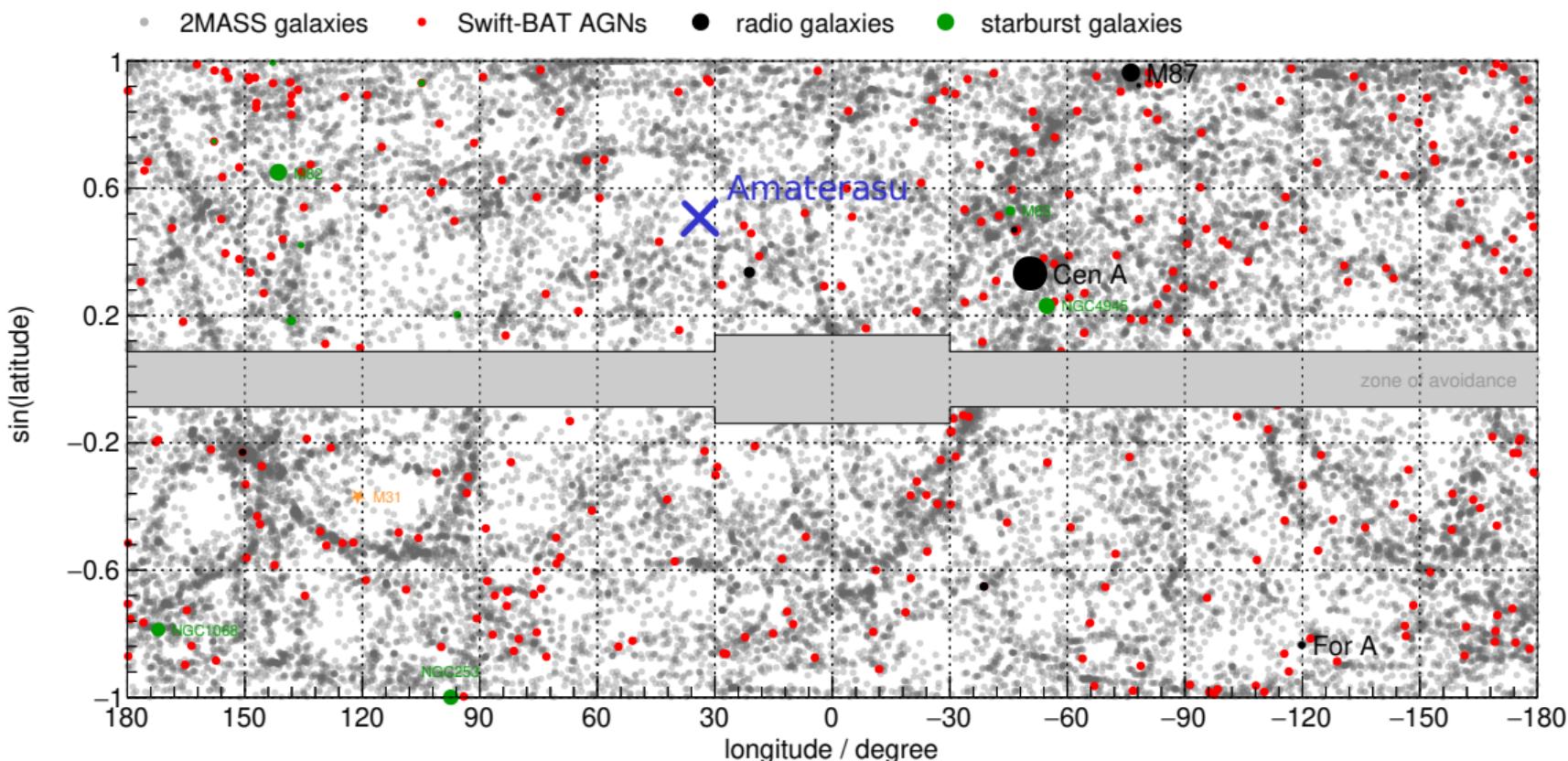
Beschleuniger LHC

7,000,000,000,000 eV

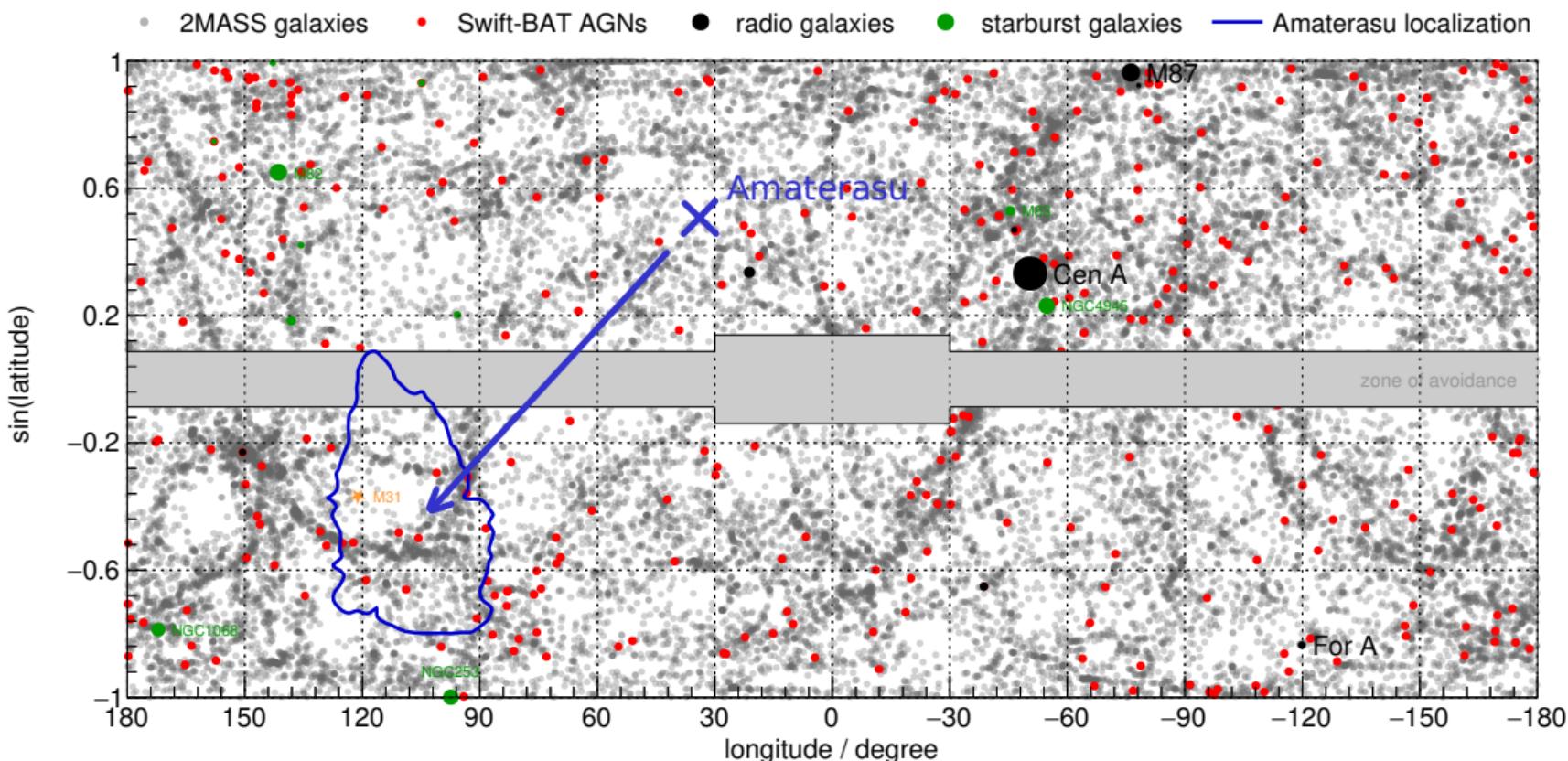
Amaterasu

244,000,000,000,000,000 eV

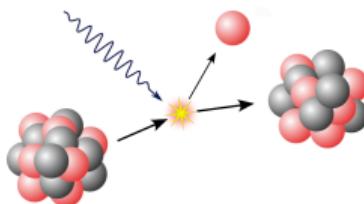
Galaxien in der kosmischen Nachbarschaft ($D \leq 500$ Millionen Lichtjahre)



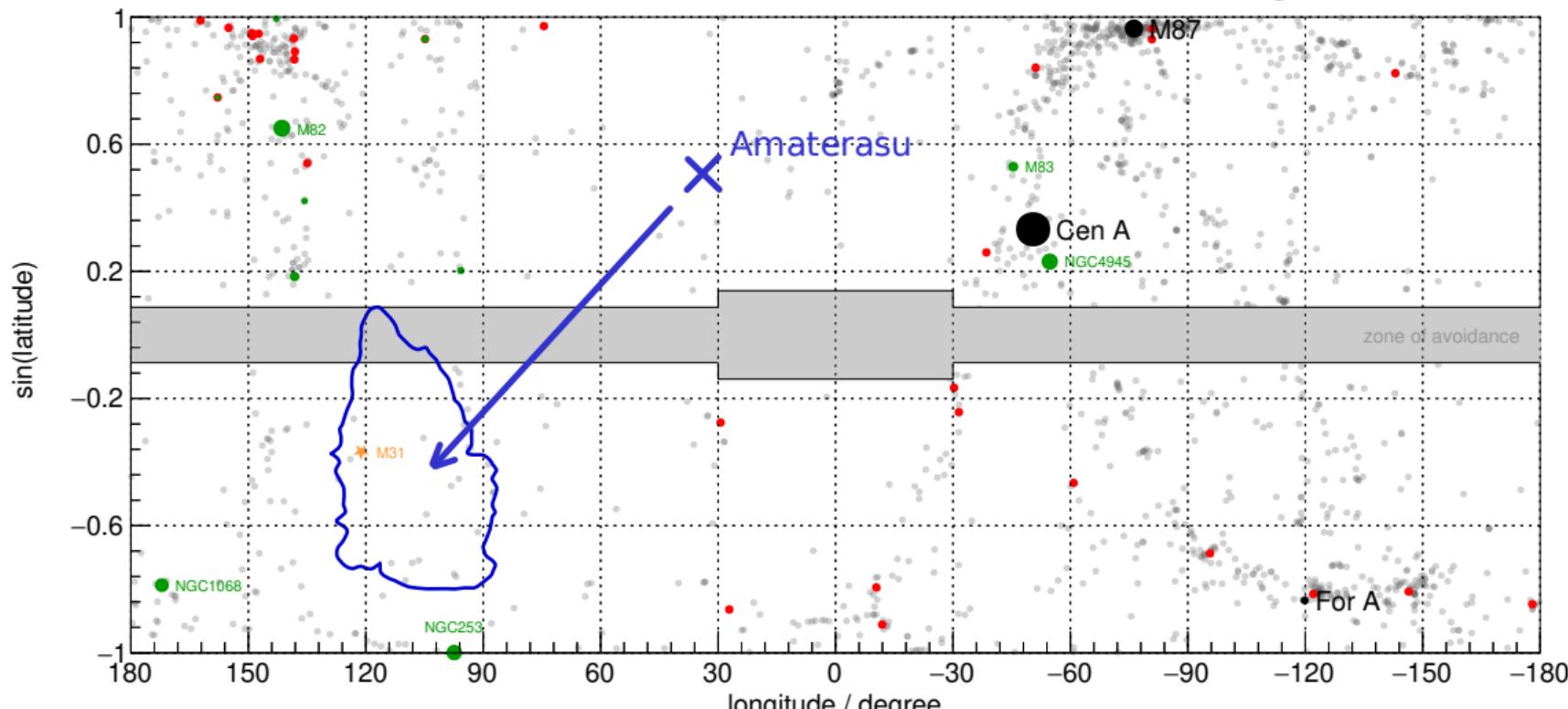
Galaxien in der kosmischen Nachbarschaft ($D \leq 500$ Millionen Lichtjahre)



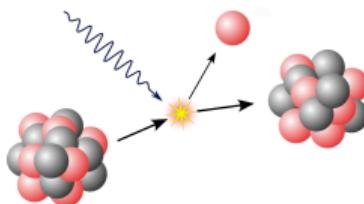
Galaxien im Teilchenhorizont ($D \leq 80$ Millionen Lichtjahre)



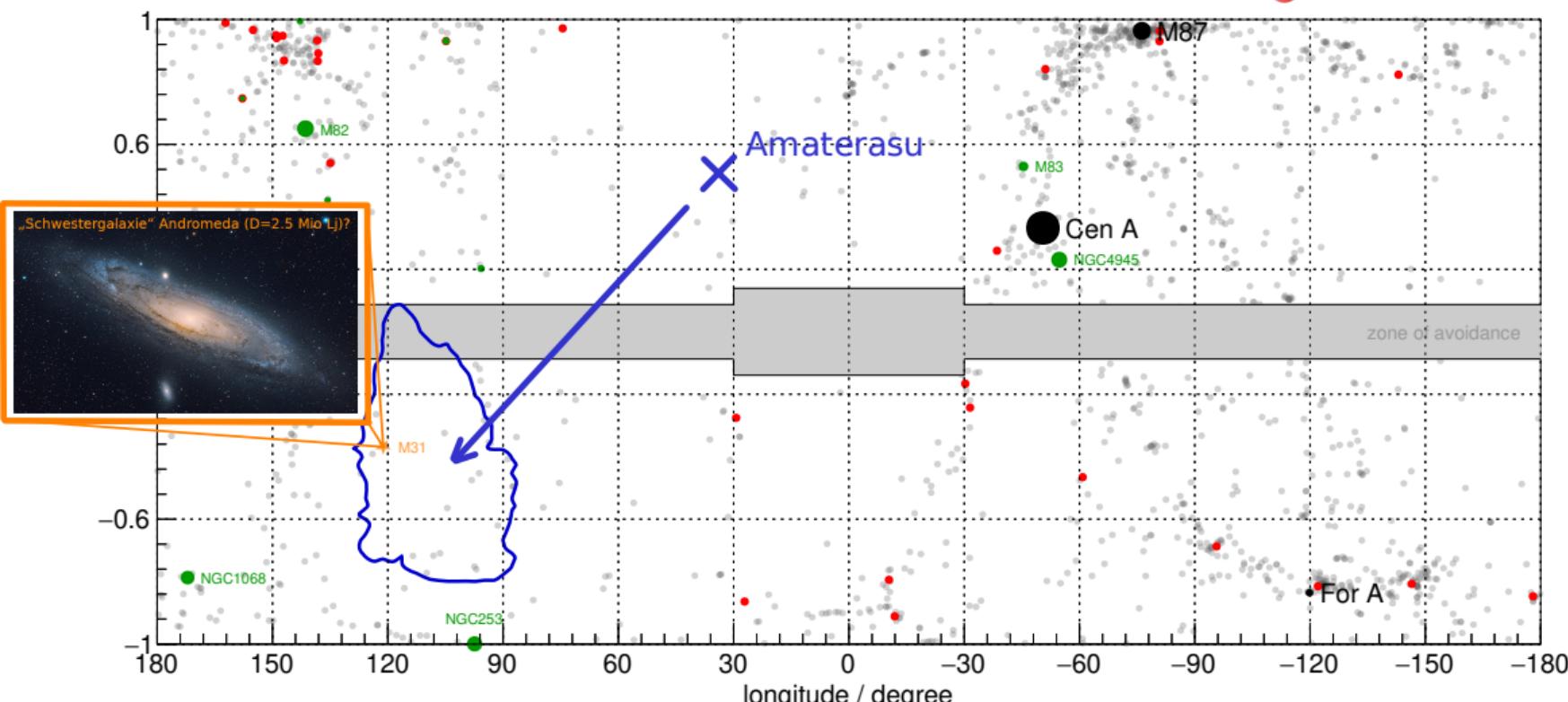
- 2MASS galaxies
- Swift-BAT AGNs
- radio galaxies
- starburst galaxies



Galaxien im Teilchenhorizont ($D \leq 80$ Millionen Lichtjahre)



- 2MASS galaxies
- Swift-BAT AGNs
- radio galaxies
- starburst galaxies



Astroteilchen in kosmischen Magnetfeldern

- Astrophysikalische Magnetfelder existieren auf allen Skalen (Erde ... Universum)
- Ursprung noch nicht endgültig geklärt (Dynamo?)
- Ablenkung geladener Teilchen in kosmischen Magnetfeldern
- Neues Modell des Magnetfeldes der Milchstraße
- Erfolgreiche Beschreibung der Ankunftsrichtungen auf großen Winkelskalen
- Ursprung des *Amaterasu*-Teilchens?