Multi-wavelength signals from a new Kaluza-Klein dark matter

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WIMPs in EXTRA-DIMENSIONS

SM of particle physics works very well except for:

- Naturalness problems
- (Neutrino masses, ...)

→ Theory beyond the SM

EXTRA DIMENSIONS

New particles (Kaluza-Klein modes) are predicted at the new physics scale ~ R^{-1}

SM of cosmology works very well but:

- Dark Matter
- (Dark Energy)

WIMPs are potentially a good solution to the DM issue.

→ Search for a WIMP among the Kaluza-Klein states.

THE MODEL

Scrucca, Serone, Silvestrini '03
Panico, Serone, Wulzer '05
Panico, Serone, Wulzer '06

5D gauge theory on S^1/Z_2 orbifold

$G = SU(3)_C \times SU(3)_W \times U(1)'$

HIERARCHY PROBLEMS

Gauge → gauge-Higgs unification

Fermion masses → SM fermions as a mixture of Dirac bulk and chiral localized fermions

DARK MATTER

Z_2 symmetry to get allowed compactification scale R^{-1}

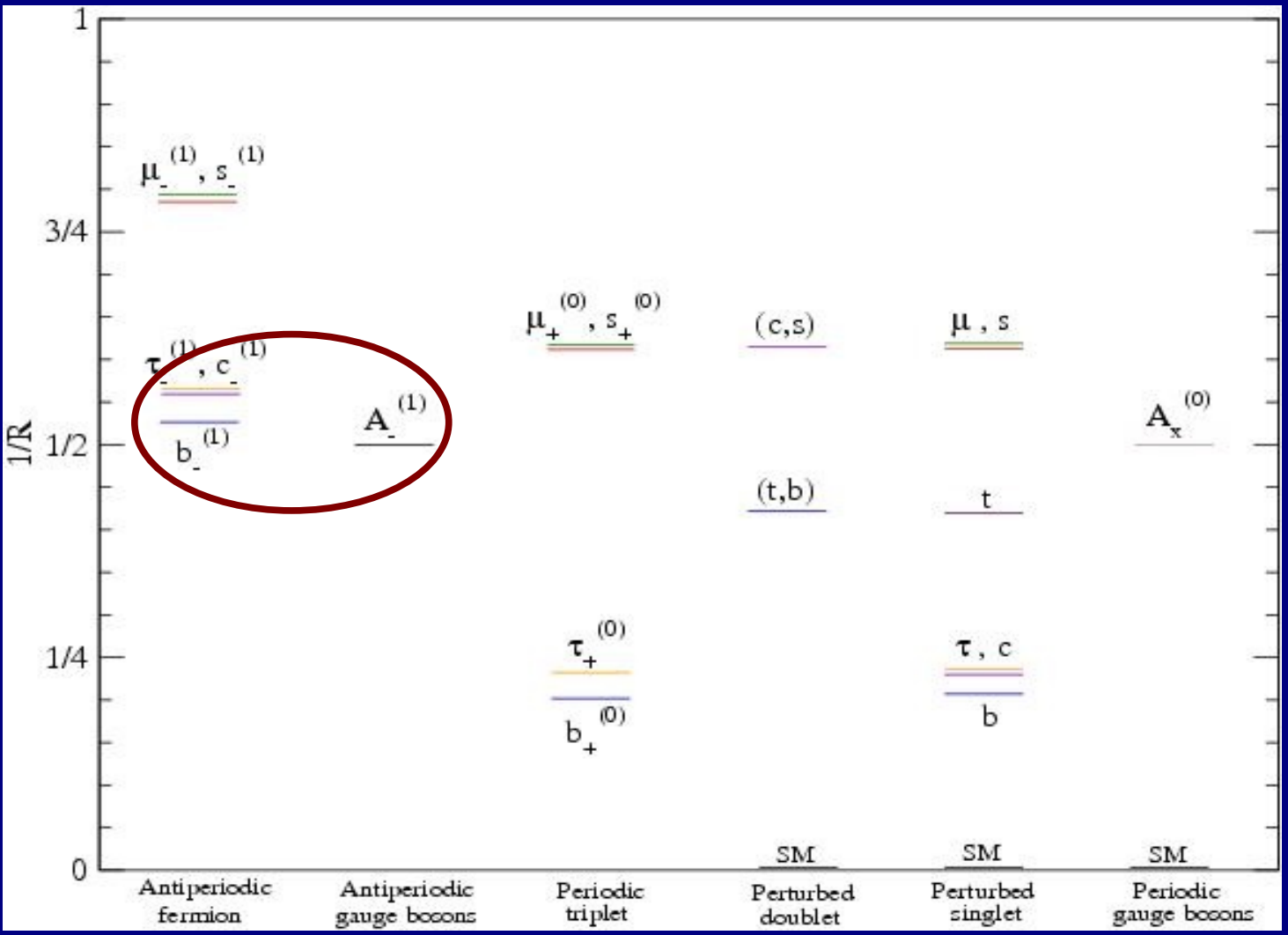
Any periodic field has its antiperiodic partner

↓

The lightest antiperiodic field is absolutely stable

DARK MATTER CANDIDATE

MR, Serone, Ullio '07



Radiative corrections can set the gauge boson $A^{(-)}$ to be the lightest antiperiodic state (with mass ~ ½ R^{-1})

The DM candidate is the gauge boson of an abelian U(1) gauge group

(like $B^{(1)}$ in UED)

RELIC ABUNDANCE

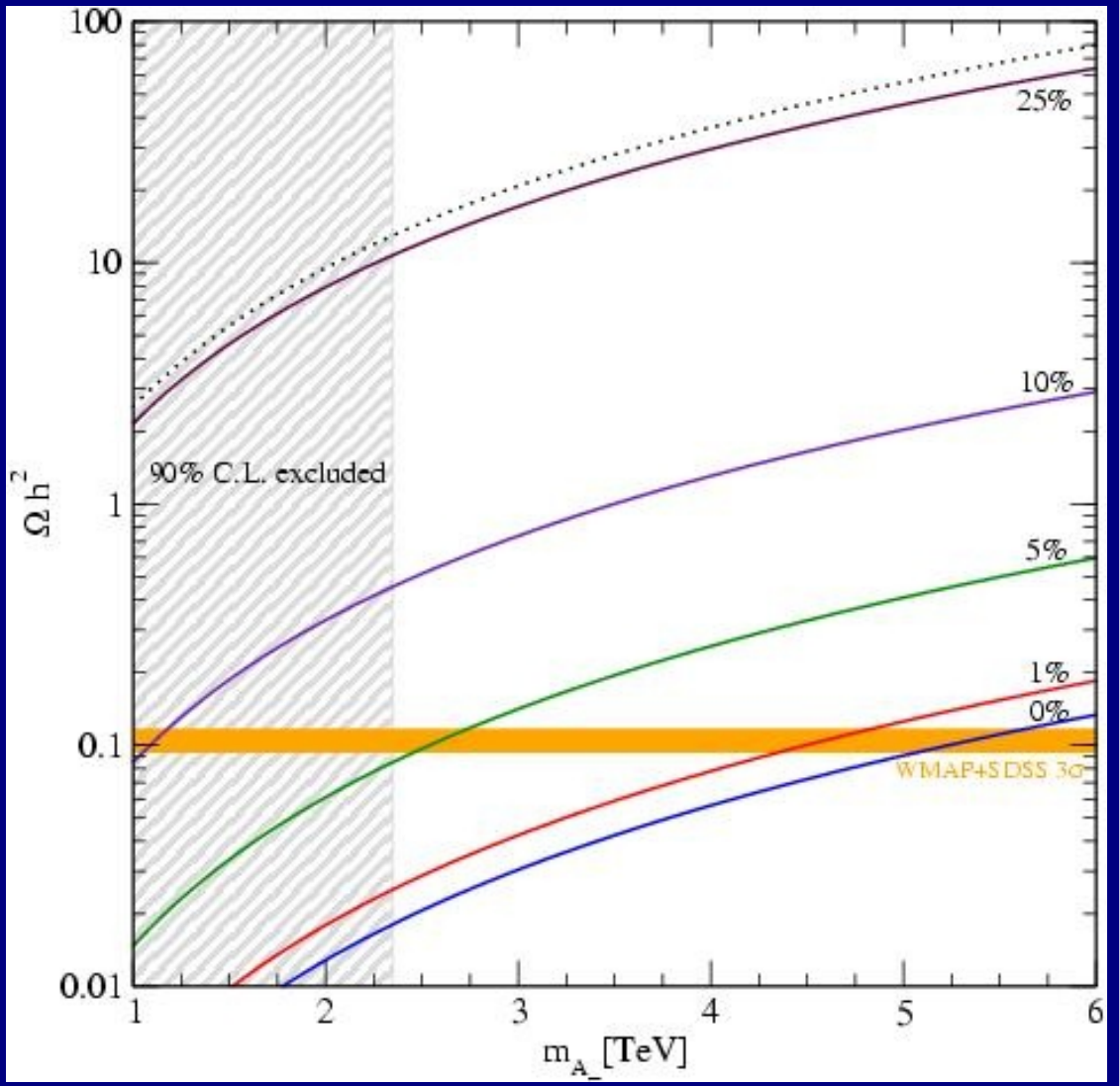
EW bound on compactification radius: $R^{-1} > 4.7$ TeV

- $A^{(-)}$ coupled only to bulk fermions
- SM fermions mainly composed by boundary fermions

→ small annihilation cross section

BUT coannihilations with colored particles greatly enhance the effective annihilation cross section

WIMP with allowed relic abundance!



DARK MATTER SIGNALS

MR, Ullio, preliminary results

Small couplings with SM fermions → No detectable signals in DM direct detection experiments

Small number density since mass ~ MultiTeV

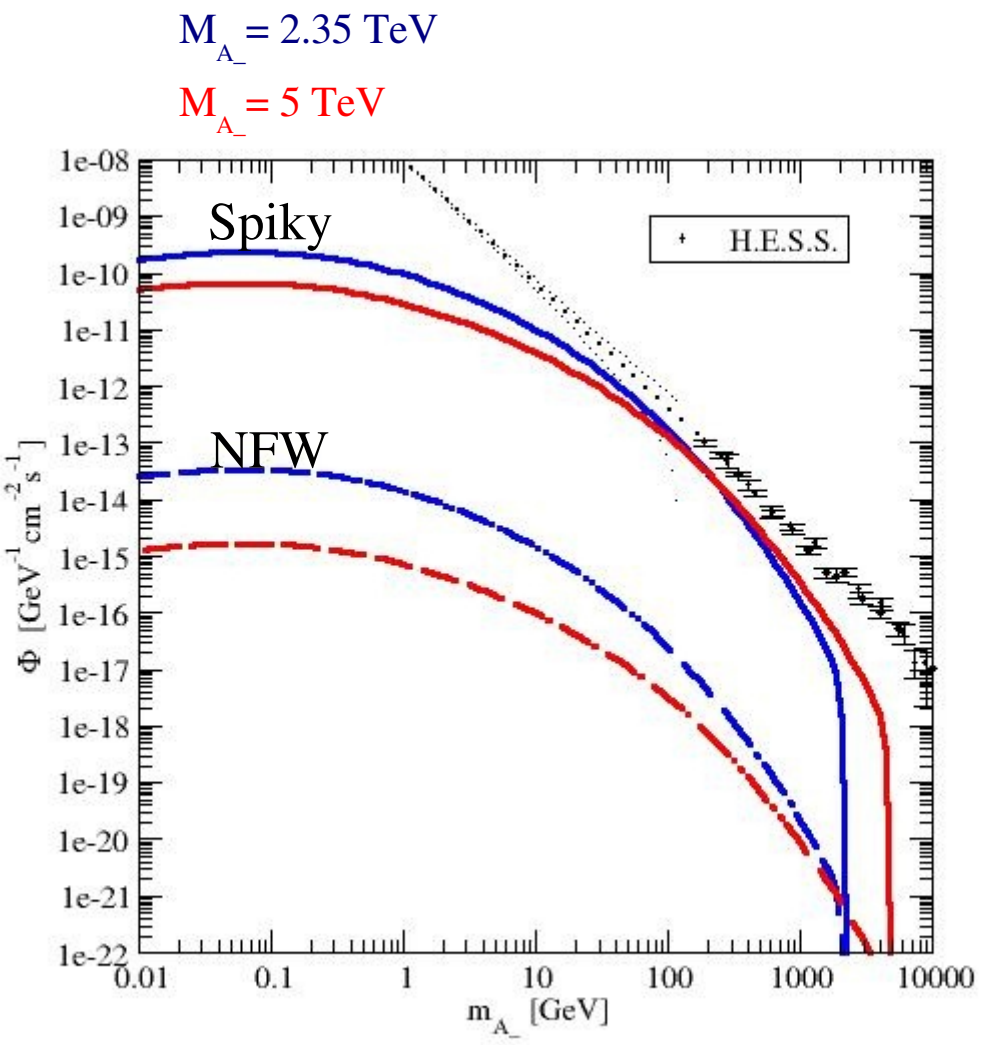
Annihilation cross section $\langle\sigma v\rangle_{ann} \sim 10^{-28}\,cm^3\,s^{-1}$

→ Need of a very dense DM region to detect a signal in indirect experiments

Dark Matter at the GC can be accreted by the central supermassive black hole into a very dense spike.
Dark Matter profile (Bertone, Merritt '05) and consequently annihilation at the Galactic Center region can be significantly enhanced.

GAMMA RAYS (continuum)

Continuum signal from π^0 decay

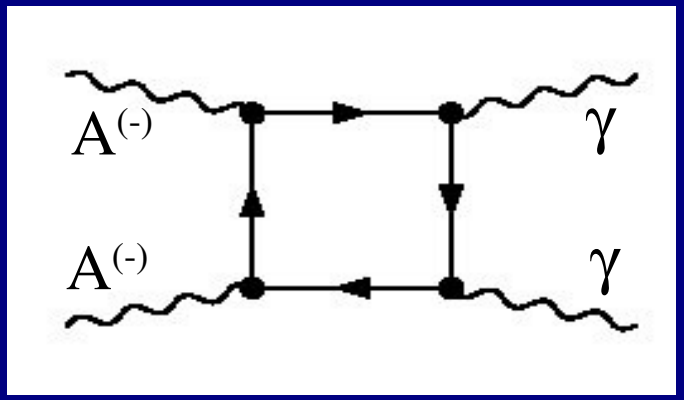


Compatible (i.e. invisible) with HESS data

Essentially no deviation from the expected background in the GLAST energy range.

Possible small deviation in the next generation of Air Cherenkov Telescope (CTA)

GAMMA RAYS (line)



$\langle\sigma v\rangle_{line} \sim 10^{-31}\ cm^3\ s^{-1}$

Effective area = $3\ 10^7\ m^2$

Energy resolution = 10%

Angular resolution = 0.1^o

Misidentified hadrons = 1%

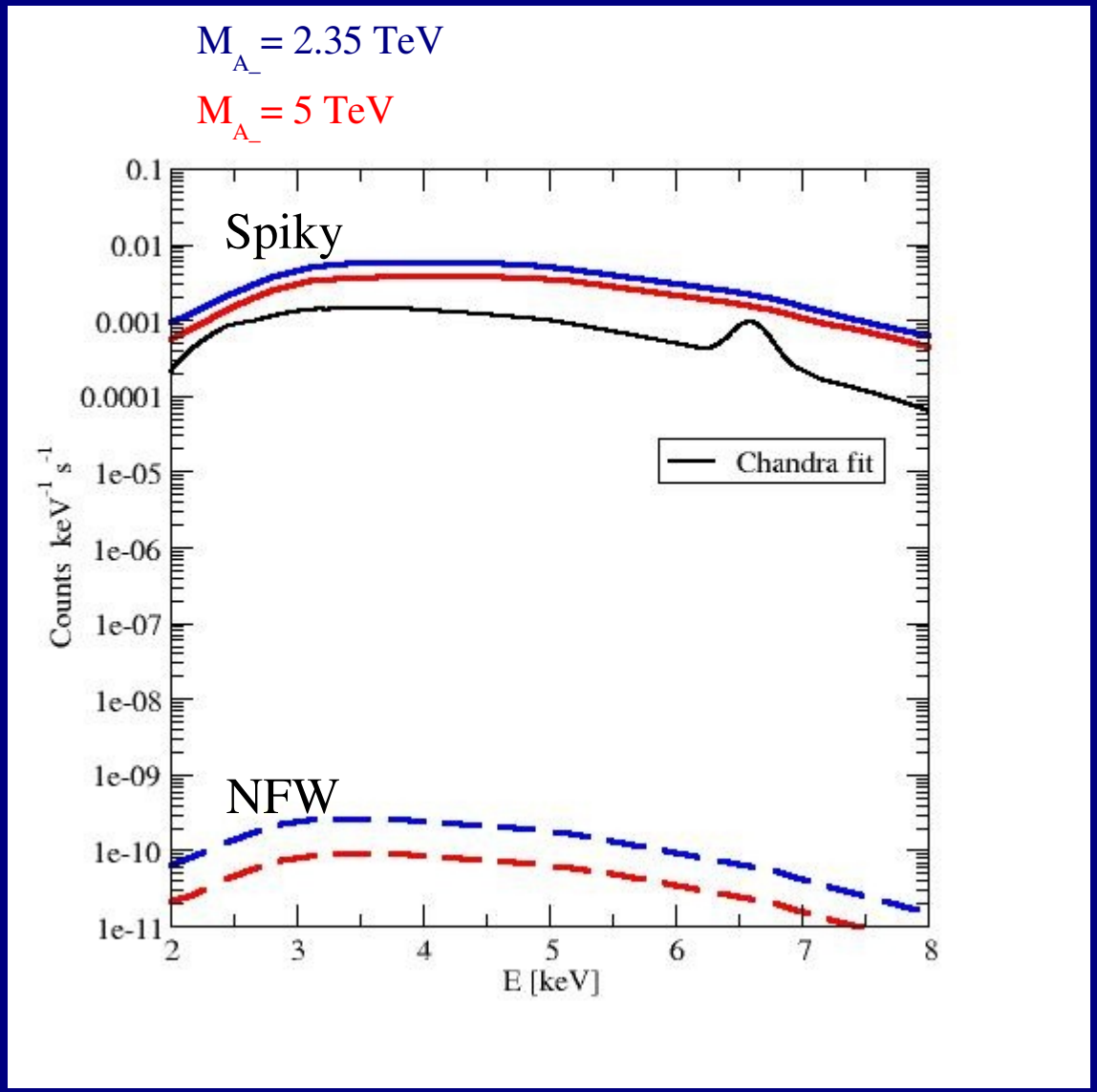
→ Potentially detectable by the Cherenkov Telescope Array project

$$\frac{N_{line}}{\sqrt{N_{bg}}} = 5.1$$
in 10 days

BUT systematics? $F_{line} \sim 1.5\%\ F_{tot}$

SYNCHROTRON EMISSION (X-Ray)

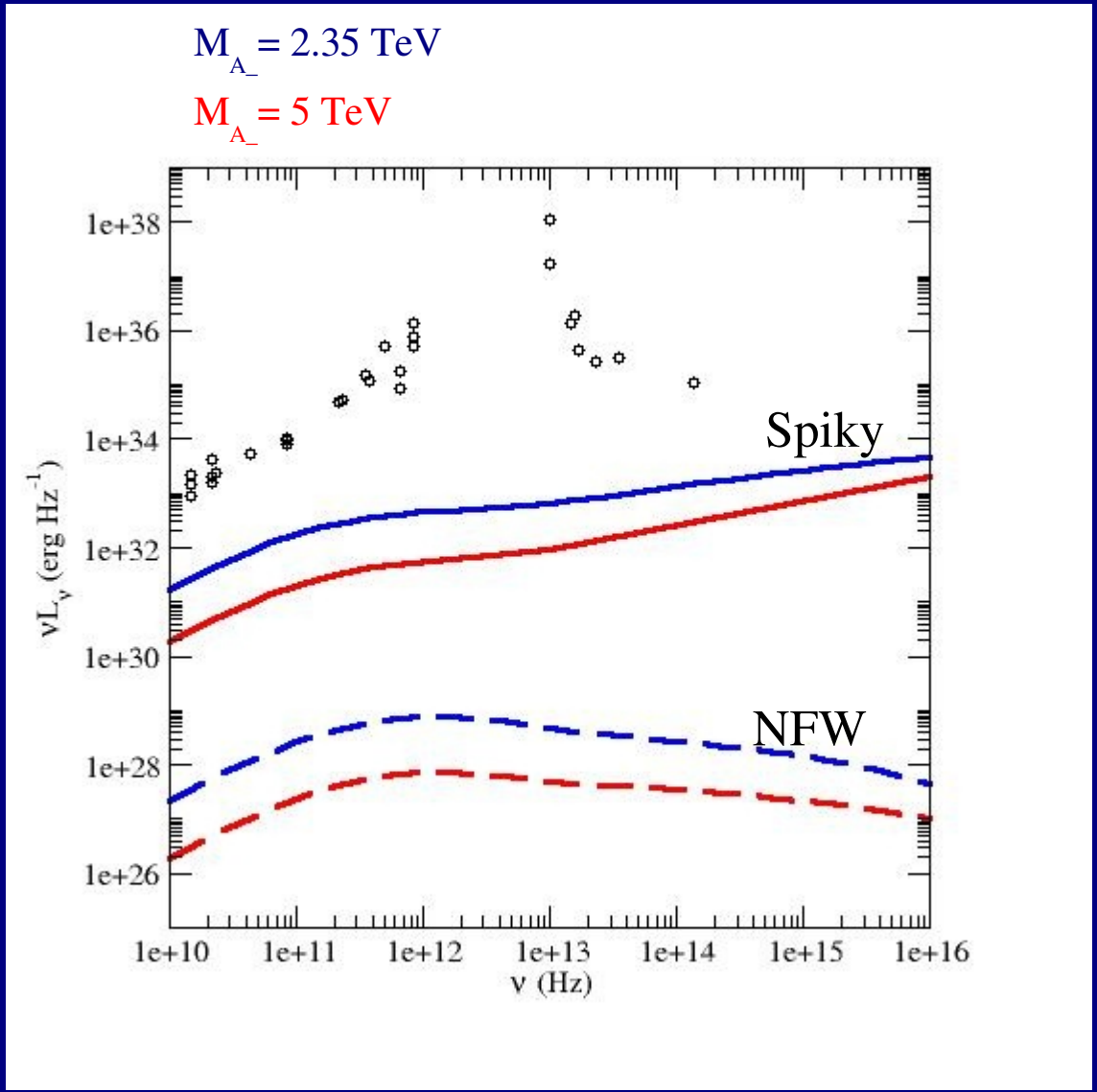
Strong magnetic field at the GC ⟷ Strong synchrotron emission for spiky profile



Signals at the same order of Sgr A* quiescent emission measured by Chandra BUT difficult to be ruled out (magnetic field uncertainties) and unpleasable as bulk of the measured flux (variability, line)

SYNCHROTRON EMISSION (Radio)

Very efficient dust absorption in the UV band.



Radio and NIR signals:

Safely below current constraints also for spiky profile

CONCLUSIONS

A new bosonic WIMP dark matter is proposed

- **Rather unusual picture**: mass in the Multi-TeV region and small coupling with SM matter fields.
- **Different framework from UED:** lack of simplicity, possible solution to hierarchy problems, not ad hoc boundary terms
- No region of parameter space ruled out by DM annihilation signals for NFW profile.
- **Testable (in the next future) phenomenology at the GC for spiky profile.**

EXPLICIT LORENTZ SO(4,1)/SO(3,1) VIOLATION

$$L = \ldots + \bar{\Psi}_i \not{D} \Psi_i + k_i \bar{\Psi}_i \not{D}^{(5)} \Psi_i + \tfrac{1}{4} F_{\mu\nu} F^{\mu\nu} + \tfrac{1}{2} \rho_a{}^2 F_{\mu 5} F^{\mu 5}$$

H

MASS OF
ANTIPERIODIC STATES

$$m_{g-}^{(2n-1)} = \rho_a \frac{(n-1/2)}{R},$$

$$m_{A-}^{(2n-1)} = \rho \frac{(n-1/2)}{R}.$$

$$m_{i-}^{(2n-1)} = \sqrt{M_i^2 + k_i^2 \left(\frac{(n-1/2)}{R}\right)^2}$$