XXXVIIth Rencontres de Moriond
ELECTROWEAK INTERACTIONS AND UNIFIED THEORIES
Les Arcs March 9th to 16th, 2002

SGOLDSTINOS : PRIMARIES OF ULTRA-HIGH ENERGY COSMIC RAYS ?

D.S.Gorbunov

- In any model with SUSY being spontaneously broken exists goldstino supermultiplet (S, P, ψ, $\bar{\psi}$)
- In a set of models sgoldstinos are light ($m_{S(P)} < 1$ GeV), long-living, but strongly interacting.
- Ultra-high energy cosmic ray (UHECR) data require new physics
- Very few models of new physics are consistent with UHECR data
- A phenomenologically viable model which is consistent: LIGHT SGOLDSTINO

SGOLDSTINO: WHERE DOES IT COME FROM ?

broken SUSY: $\Phi = \phi + \sqrt{2}\theta\psi + \theta^2 F_\phi$, $\langle F_\phi \rangle \equiv F \neq 0$

ψ — goldstino, $\mathcal{L}_{int} = \frac{1}{F} J_\mu^{SUSY} \partial^\mu \psi + h.c.$

$\frac{1}{\sqrt{2}}(\phi + \phi^*) \equiv S$ — scalar sgoldstino

$\frac{1}{i\sqrt{2}}(\phi - \phi^*) \equiv P$ — pseudoscalar sgoldstino

MSSM soft SUSY breaking terms & F

$\Downarrow$

$\mathcal{L}_{int}\,(S, P \leftrightsquigarrow SM\ fields)$

high order terms from Kähler potential

$\Downarrow$

m_S, m_P

$M_{SUSY} \sim 100$ GeV $\Rightarrow$ free parameters: F, m_S, m_P

SGOLDSTINO:

LONG-LIVING & STRONGLY INTERACTING

$m_S < 1$ MeV

$$\mathcal{L} \sim \frac{M_{\gamma\gamma}}{F} S F_{\mu\nu} F_{\mu\nu}, \quad M_{\gamma\gamma} = M_1 \cos^2\theta_W + M_2 \sin^2\theta_W$$

$$\Gamma(S \to \gamma\gamma) = \frac{M_{\gamma\gamma}^2 m_S^3}{32\pi F^2}, \qquad F \nearrow,\ m_S \searrow \ \Rightarrow\ \tau_S \nearrow$$

$\Downarrow$

sgoldstino may be long-living

$$\mathcal{L} \sim \frac{M_3}{F} S G^a_{\mu\nu} G^a_{\mu\nu} \qquad \alpha_{eff} = \frac{M_3^2 E^2}{4\pi F^2}$$

at high energy: $E \nearrow \ \Rightarrow\ \alpha_{eff} \nearrow$

$\Downarrow$

sgoldstino may be strongly interacting

ASTROPHYSICS & COSMOLOGY

(SN explosion, CMB spectrum, ...)

$\Downarrow$

constraints on the parameters

UHECRs: EVIDENCE FOR NEW PHYSICS?

- Observed flux of UHECRs above $E > 4 \cdot 10^{19} eV$:

  no GZK cutoff

- Small-scale clustering

- Correlations of arrival directions with

  BL Lac type objects

$\Downarrow$

primary particles travel for $\gtrsim 200$ Mpc and do not attenuate on CMB

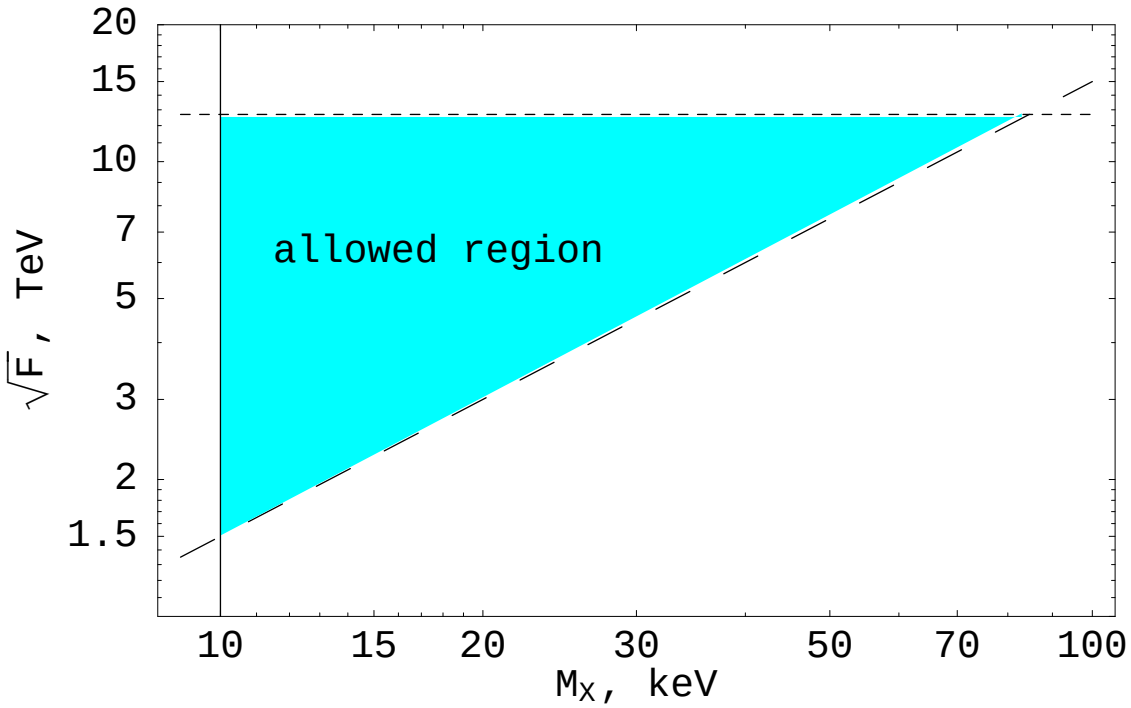
Who are the primaries of UHECRs?

SGOLDSTINO ? — WHY NOT?!

SGOLDSTINO PRIMARIES: A VIABLE MODEL

- $l_S \gtrsim R_U \Rightarrow$ only $S \to \gamma\gamma$ is relevant
- should be produced in the sources $\Rightarrow$ $p + p \to S + ...$
- should produce atmospheric showers

  $l_S^{atm} \lesssim 10 \cdot l_p^{atm}$. and $l_S^{atm} \sim l_p^{atm} \cdot \dfrac{\alpha_s}{\alpha_{eff}}$
- all experimental constraints from A&C are satisfied



Allowed region for the parameters (m_S, $\sqrt{F}$)

(at $M_{\gamma\gamma} = 100$ GeV, $M_3 = 500$ GeV)

LIGHT SGOLDSTINO: MAY BE TESTED IN LABORATORY AND COLLIDER EXPERIMENTS

- $\Upsilon \to S\gamma$, $J/\psi \to S\gamma$
- reactor experiments
- $\sqrt{F} \sim 1 \div 10$ TeV $\Rightarrow$ searches for light sgoldstinos and gravitinos at colliders

One can try to find explanations for other A&C puzzles within the models with light sgoldstinos

i.e., Dimming of SN Ia by sgoldstino-photon conversion.