SUSY is not the solution to the dark matter crisis

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On 19 August 2016, the 'SUSY Bet' event took place in Copenhagen at the conference on Current Themes in High Energy Physics and Cosmology at the Niels Bohr International Academy. An adjudication of the wager on supersymmetry (SUSY) first made in 2000 was given. The detail of the wager is explained in figure 1.

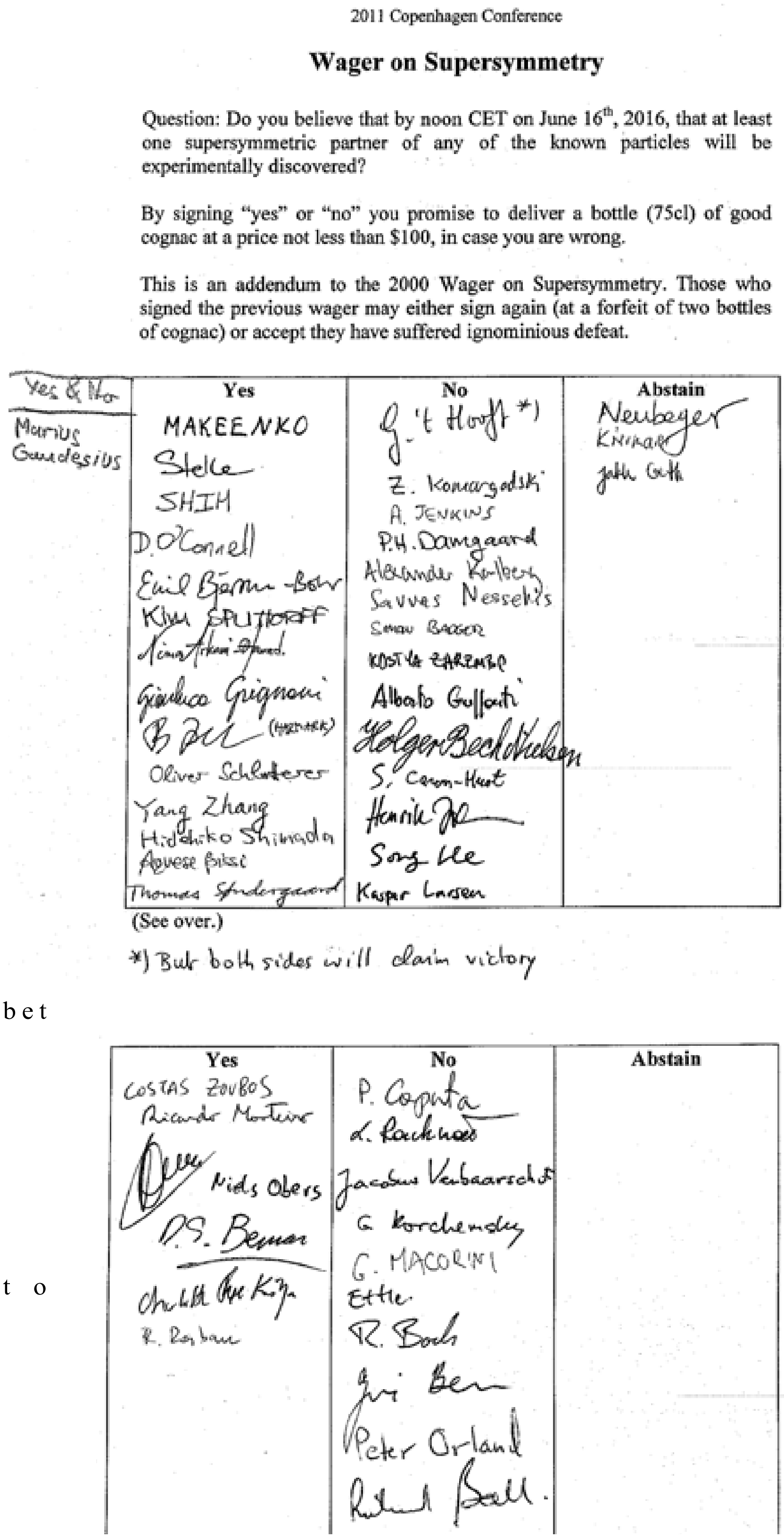
Supersymmetry

What is supersymmetry? In particle physics, supersymmetry is a proposed type of spacetime symmetry that relates two basic classes of elementary particles: bosons, which have an integer-valued spin, and fermions, which have a half-integer spin. Each particle from one group is associated with a particle from the other, known as its superpartner. It has been these supersymmetric partner particles that have been sought in high energy particle experiments.[1]

The bet involved two aspects of supersymmetry theory:

1. That after 10 years (from 2000) the Large Hadron Collider (LHC) would have collected enough experimental data to confirm or deny the existence of the supersymmetric particles that the theoretical physicists were thinking about at that time.
2. That supersymmetric particles with sufficiently low masses would be discovered like "sitting ducks" (as Gerard 't Hooft put it).

At the event the 'Yes' side of the bet, who believed the particles would be detected, conceded the loss of the



2011 Copenhagen Conference

Wager on Supersymmetry

Question: Do you believe that by noon CET on June 16th, 2016, that at least one supersymmetric partner of any of the known particles will be experimentally discovered?

By signing "yes" or "no" you promise to deliver a bottle (75cl) of good cognac at a price not less than $100, in case you are wrong.

This is an addendum to the 2000 Wager on Supersymmetry. Those who signed the previous wager may either sign again (at a forfeit of two bottles of cognac) or accept they have suffered ignominious defeat.

Yes & No
Marius Gaudesius

Yes	No	Abstain
MAKEENKO	G. 't Hooft *)	Neuberger
Stelle	Z. Komargodski	Knikar
SHIH	A. JENKINS	John Gath
D.O'Connell	P.H. Damgaard	
Emil Bjerrum-Bohr	Alexander Kolberg	
Kim SPLITTORFF	Savvas Nesseris	
Nima Arkani-Hamed	Simon BADGER	
Gianluca Grignani	KOSTYA ZAREMBO	
(HARVARD)	Alberto Guffanti	
Oliver Schlotterer	Holger Bech Nielsen	
Yang Zhang	S. Caron-Huot	
Hidehiko Shimada	Henrik	
Agnese Bissi	Song He	
Thomas Søndergaard	Kasper Larsen	

(See over.)

*) But both sides will claim victory

bet

Yes	No	Abstain
COSTAS ZOUBOS	P. Caputa	
Ricardo Monteiro	L. Rockwood	
Niels Obers	Jacobus Verbaarschot	
D.S. Berman	G. Korchemsky	
Charlotte Kristjansen	G. MACORINI	
R. Rosbaum	Ettle	
	R. Bach	
	Jiri Ben	
	Peter Orland	
	Richard Ball.	

to

the

Figure 1. Details of the famous SUSY Bet, adjudicated on 16 August 2016

'No' side. The bet was meant to be decided on 16 June 2016, if no SUSY particle was detected after effectively 10 years of operation of the LHC. The adjudication of the bet was extended by the 'No' side by an additional six years due to delays in getting the LHC online, which included a two-year delay due to an explosion.

On the larger question of the significance of the negative LHC results, a recorded video statement by Nobel Laureate Gerard 't Hooft (who had bet against SUSY) can be viewed online,[2] and a statement by Stephen Hawking (not in on the bet, but in the audience) claimed that if arguments for SUSY were correct, the LHC should have seen something, so they think nature has spoken and there's something wrong with the idea.

The losers of the bet who spoke at the event—Nima Arkani-Hamed, David Gross and David Shih—demonstrated the lesson about science that supersymmetry and superstring theory have taught us: particle theorists backing these ideas won't give up on them, no matter what. They all took the position that they still weren't giving up on SUSY, despite losing the bet.

Gerard't Hooft commented that all evidence so far has been circumstantial at best. No direct evidence has ever been found in support of supersymmetry and hence string theory, because SUSY would be an essential element in string theory.[3] String theory does not have any experimental support and SUSY has not fulfilled its promise, therefore it does not help us trust in such a theory. Therefore he found the 'No' side won the bet.

Dark matter

We all know that the Higgs boson—the so-called God particle—was discovered after the LHC became fully operational, but SUSY has not been established. And the Higgs discovery has meant some very important restrictions on the type of fields the universe might have undergone in the alleged cosmic inflation epoch.[4] However there is one more ramification.

It was hoped that the lowest mass SUSY particle would turn out to be a dark matter candidate. Now that observations have ruled out MACHOs[5] as possible candidates for dark matter, WIMPs (or Weakly Interacting Massive Particles) are the only remaining contender. They comprise an entirely new class of fundamental particles that has emerged from supersymmetry theory.[6]

Supersymmetry is a theoretical idea where known elementary particles have supersymmetric partner particles.[1] This is not part of the highly successful, and experimental tested, standard model of particle physics, but is an untested theoretical extension beyond the standard model. In the so-called Minimal Supersymmetric Standard Model (MSSM), which was hypothesized to explain the hierarchy problem (which is, why elementary particles have the various masses they do), *the lightest stable supersymmetric particle is the neutralino. And the neutralino is the WIMP, the best hope for a dark matter particle.*[6]

Conclusion

With the non-detection of any SUSY particles and the essential demise of string theory (that is how good experimental physics should work) it also does not bode well for dark matter. The dark matter crisis has just gotten into a bigger crisis. The best candidate has been experimentally shown now to be extremely improbable. Where does that leave dark matter and the standard model of particle physics? Where does that leave the standard big bang model and big bang nucleosynthesis? In big, big trouble. It is a failed paradigm and should be discarded.

References

1. According to the theory, each particle from one group is associated with a particle from the other, known as its superpartner, the spin of which differs by a half-integer. In a theory with perfectly 'unbroken' supersymmetry, each pair of superpartners would share the same mass and internal quantum numbers besides spin. For example, there would be a 'selectron' (superpartner electron), a bosonic version of the electron with the same mass as the electron, that would be easy to find in a laboratory. Thus, since no superpartners have been observed, if supersymmetry exists it must be a spontaneously broken symmetry so that superpartners may differ in mass. Spontaneously broken supersymmetry could solve many mysterious problems in particle physics including the hierarchy problem. The simplest realization of spontaneously broken supersymmetry, the so-called Minimal Supersymmetric Standard Model, is one of the best studied candidates for physics beyond the Standard Model.
2. SUSY Bet 2016, youtube/As9raVaTFGA.
3. Superstring theory is an attempt to explain all of the particles and fundamental forces of nature in one theory by modelling them as vibrations of tiny supersymmetric strings. 'Superstring theory' is a shorthand for supersymmetric string theory because unlike bosonic string theory, it is the version of string theory that accounts for fermions and incorporates supersymmetry. Since the second superstring revolution, the five superstring theories are regarded as different limits of a single theory tentatively called M-theory, or simply string theory.
4. Hartnett, J.G., Inflation—all in the 'Dark', The Higgs boson messes with cosmic inflation, creation.com/ inflation-all-in-the-dark, July 2014.
5. MACHO = Massive Compact Halo Objects, which some believe are brown dwarf stars. But if they are, too few were found in searches for them to have any bearing on the dark matter crisis.
6. Cold Dark Matter and Experimental Searches for WIMPs, www.astro.umd.edu/~ssm/darkmatter/WIMPexperiments.html, accessed on 2 September 2016.