**Reviewer 1**

**Comment 1:**

Reviewer’s comment: “*The technical results sound convincing, but such an effect has already be observed in many experiments related to the idea of Quantum Non Demoltion (QND) measurements, which start by entangling the relevant system with ancilla systems; to get a meaningful result all the ancillas have to « agree » about it. A well-known example is the measurement of the photon number by many atoms crossing a high-finesse cavity, as carried out several years ago by the Haroche group in Paris. There are also experiments with chains of trapped ions, and with NV centers. In the present experiment it is said that the spins are « naturally » evolving, but clearly this is not relevant for the main effect, ie for building up the correlations.* “

Indeed, the QND experiments are now cited in the context of the creation of the GHZ-like state (“In addition, previous work on the field...”). There are, however, important differences in the context of the main finding of our work: After demonstrating the control protocol by creating an artificial state, we show that a quantum system naturally being decohered by its environment proliferates redundant information about its pointer states. That this happens shows how the classical, objective world emerges from the underlying quantum substrate: It is the inevitable copying of information, not by design, but simply by the fact that systems tend to interact with many components of the environment.

**Comment 2:**

Reviewer’s comment: “So basically the the authors are performing a quantum measurement of the electron spin, so far so good. However, the main focus of the article is to interpret this measurement through the quantum Darwinism picture, and they write claims such as « This provides the first laboratory verification of the objective classical world emerging from the underlying quantum substrate » or « To conclude, these results give the first laboratory demonstration of quantum Darwinism in action in a natural environment ». Clearly the tone is to claim that the observed results prove experimentally the validity of quantum Darwinism (in action !). Unfortunately such a presentation sounds quite overselling and unwarranted. Certainly the results are compatible with the quantum Darwinism picture, but they would be compatible as well with any other decent interpretation of quantum measurements. A good proof is that the many other QND-like experiments quoted at the beginning did not use quantum Darwinism to get an « explanation of the origin of classical reality in our quantum world » - this would be quite ambitious indeed.”

We agree that QND and the employment of quantum measurements does not give an explanation of classical reality. However, it is the differences highlighted in the response to the previous comment that allow one to draw conclusions about how the objective classical world emerges, irrespective of our ability to perform QND and other measurements.

**Point 1:**

Reviewer’s point: “*refer to many other experiments involving coupling to (more or less noisy) ancillas*”

We added additional references when we introduce our spin system (“Such a platform...”).

**Points 2 & 3:**

Reviewer’s points: “*say clearly that the results may be in interpreted in the framework of quantum Darwinism, but may also be interpreted without it …[and] not claim that it provides an « explanation of the origin of classical reality in our quantum world », but more modestly that it agrees with quantum Darwinism.* ””

We revised the manuscript to make more explicit that the artificial creation of GHZ and GHZ-like states is without repercussions for interpretation. However, the appearance of redundant information under natural decoherence is what we claim in the original manuscript: It is quantum Darwinism in action and its first laboratory demonstration.

**Point 4:**

Reviewers comment: “*in the same spirit, in the title "Illustrating..." would be more appropriate than "Revealing..." that sounds almost religious.*”

The dynamical control protocol we implement enabled us to microscopically examine the decoherence process and see the development of redundant information. That is, it revealed the underlying process responsible for emergence objective, classical world. “Illustrating”, in our mind, actually assumes that the principle we examine (quantum Darwinism) is true to begin with and suggests that we just look at an example of it.

**Reviewer 2**

**Point 1:**

Reviewer’s comment: “*The writing in general is quite clear. However, occasionally some technical terms are not explicitly defined or explained with the burden of checking references on readers. For example, what is the definition of Holevo quantity?*”

We regret not giving a more thorough account of this. The Holevo quantity is introduced in the new version of the manuscript right where it first appears (after Eq. (5)).

**Point 2:**

Reviewer’s comment: “*Holevo quantity gives only the UPPER bound of the classical information. Would this affect the conclusion of information redundancy? If yes, can classicality still be claimed? If not, why?*”

Yes, classicality (redundancy of information) can still be claimed. The tomography process yields the density matrix, from which we can directly compute the accessible information deposited into parts of the environment.

**Point 3:**

Reviewer’s comment: “*In Eq. (4), should the "+" sign in front of H\_{SF} be a "-" sign?*”

Yes, the “+” should be a “-“. In the resubmitted manuscript this typo is corrected.

**Point 4:**

Reviewer’s comment: “*What is the definition of entangling gate in the last paragraph of page 3? What is H^j in the formula for R?*”

This was an accidental change in notation. We changed H^j to H^k which is defined in Eq. (7).

**Point 5:**

Reviewer’s comment: “*The bars for pi pulses and composite pi pulses in Fig. 2b are hardly distinguishable. The bars in Fig. 2c overlap with the shadow of the curves, making it very difficult to tell how the deviation is.*”

We thank the reviewer for pointing this out. We use now another color for the bars of the composite pulses in Fig. 2b. We also removed the bars in Fig. 2c.

**Point 6:**

Reviewer’s comment: “*The Holevo quantity has been normalized by the initialization and control errors. Would this "normalization" affect the claim of information redundancy? The authors should clearly comment on this point.*”

The absolute amount of redundancy is different when normalization with respect to the limited initial nuclear spin polarization and correction of error coming from readout are taken into account compared to only the faulty readout. In our manuscript, we present both cases. Normalization is based on careful characterization of initialization and readout error. It thus takes only faulty (and well characterized) processes before and after the buildup of nuclear-electron spin correlations into account. Comparing our results with the results of simulations shows that error during nuclear-electron spin interaction are negligible.

We clarified this point in the revised manuscript on page five (“The absolute amount of redundancy is therefore different...”).

**Point 7:**

Reviewer’s comment: “*Why in Fig. 3c only the data of 3 nuclear spins are presented?* ”

To show the creation of the GHZ state only the three most strongly coupled nuclear spins were used.

We state now in an additional place that for demonstrating our capability to produce a GHZ state we only used the three strongest coupled nuclear spins.

**Point 8:**

Reviewer’s comment: “*I am a little confused with the sentence "Nevertheless, even when 13C is not ..." in the 2nd last paragraph of page 5. Are the authors claiming that initiailization of bath spins is not needed to demonstrate the information redundancy?*”

We agree this sentence was confusing and is now removed.

**Point 9:**

Reviewer’s comment: “*In the first paragraph of page 6: Why do we need C-13 enriched diamond sample to extract quantum discord D? Since isolation of the nuclear spins from the rest of the bath spins is desired, I thought a C-12 enriched sample would be better. I might have missed some arguments. Then the authors should explain it more clearly.*”

This statement is to point the path forward for our platform to observe very large redundancy. Indeed, as the reviewer implies, when the concentration of C-13 increases, unwanted interaction between nuclear spin will appear. On the timescale where redundancy increases, though, these interactions can be neglected for a moderate C-13 enrichment. We clarified this point in the manuscript and mention unwanted interactions between nuclear spins in the case of a high C-13 enrichment in the SI.