ing nuclear polarizations s_L and s_R have different time dependence, generating an asymmetry between the dots, $s_L \neq s_R$. As we shall see, such asymmetry is dramatically reflected in the time-dependence of electric current.

In this work we focus on the effects in nuclear polarization dynamics due to the shot-noise arising from the discreteness of carriers passing through the system. Electrons are injected into the system one-by-one, with random spin orientations. While transiting through the dots, each such electron may exchange its spin with the nuclear subsystem. Crucially, these stochastic spin-flip processes comprise an *intrinsic* source of broadband noise that couples to nuclear dynamics. The intensity of this noise, which is proportional to the DC current, remains nonzero even when the average rates of up and down spin-flips are equal: $S \propto (\Gamma_+ + \Gamma_-)$. The resulting DNP fluctuations are relatively slow due to the large number of nuclear spins in the dots, $N \approx 10^6$, which requires many electrons to be transmitted through the system before DNP can change substantially.

Another important aspect of the double dot system is the complex relationship between the system's internal variables and measurable quantities, i.e. between the nuclear polarization and electric current. Due to the resonant energy dependence of transition rates, current is sensitive to the alignment of energy levels via a number of external and internal variables (gate voltages, magnetic field, Overhauser fields in each dot, etc). Changes in the hyperfine spin flip rates feed back into DNP dynamics, giving rise to a variety of interesting nonlinear phenomena occurring on long time scales, exemplified in Fig.1b,c. Numerical simulations based on this microscopic model, which is described in detail below, demonstrate how the complex long timescale dynamics arise from the stochastic nature of electron transport.

In particular, we find that the high frequency noise can drive intermittency in electric current resembling the multi-scale switching behavior observed in experiments, which will be discussed below. In dynamical systems, intermittency refers to the alternation of phases of apparently regular and chaotic dynamics[15]. Such behavior arises in many physical systems. For example, fluorescence intermittency, or blinking, is commonly observed in the optical repsonse of various nanoscale systems, such as large molecules or quantum dots, where it signals competition between the radiative and non-radiative relaxation pathways[16]. In our system, a commonly observed type of behavior is slow build-up followed by intermittent switching between "quiet" and highly fluctuating current states, illustrated in Fig.1b,c and Fig.2a,b.

Throughout this paper, simulation results are compared to data from the measurements described in Ref.7. Figure 2a shows typical experimental current traces observed in the regime of moderate magnetic field ($B =$ 200 mT) and with a gate voltage setting where the electrostatic energy makes lowest two singlet states, one with one electron in each dot and the other with both electrons in the right dot, nearly degenerate (i.e. near zero "detuning"). In this case, these "$(1,1)$" and "$(0,2)$" singlet states are strongly hybridized by the tunnel coupling between the dots (see Fig.3a). The traces were taken after a long waiting period which allowed the system to relax to equilibrium. Current displays dynamics on a very long time scale, with a smooth transient "slow build-up" period lasting several tens of seconds followed by a "steady-state" featuring intermittent large amplitude fluctuations with a correlation time on the scale of seconds (blue trace). The fluctuations can be abruptly suppressed by a relatively small change of detuning (red trace). Similar behavior was observed during slow sweeps of magnetic field (shown in Fig.4).

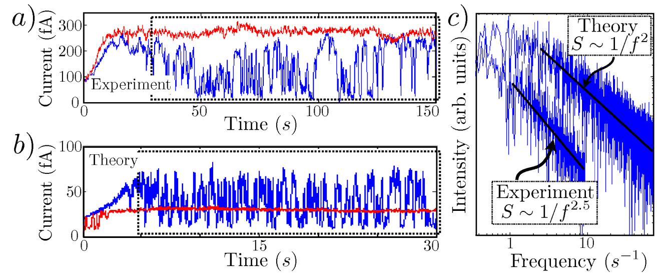

FIG. 2: Time-dependent current, from experiment[7] (a), and from simulation (b), showing a long build-up lasting several tens of seconds followed by steady-state intermittent fluctuations (blue traces). Fluctuations can be suppressed by a small change of detuning (gate voltage) which moves a fixed point away from the sensitive region $s_L \approx s_R$ (red traces). c) Fourier spectra of the experimental and simulated noisy traces, evaluated in the marked steady-state regions. The spectra display a roughly $1/f^\alpha$ dependence with $\alpha_{\rm exper.} \approx 2.5$ and $\alpha_{\rm simul.} \approx 2$.

Similar-looking fluctuations were reported by Reilly et al. as 'blinking' of the Overhauser field measured in a double-dot which was repeatedly pulsed through a singlet-triplet level-crossing[8]. There, long timescale noise correlations were attributed to nuclear spin diffusion resulting from the dipole-dipole interaction. In contrast, below we describe a mechanism where diffusion of the net nuclear polarization is not driven by the conventional dipole-dipole mediated spin flips, but rather is driven by shot noise in the current passing through the system.

The rest of the paper is organized as follows. In Section I we describe the physical mechanism of shot-noise-induced multiscale intermittent fluctuations of current. Then in Section II we present the mathematical description of our model for describing the time dependence of nuclear polarization and current in spin-blockaded double quantum dots. In Section III we present the results of simulations based on the model described in Sec.II, and compare with experimental data. Finally, our conclusions are summarized in Section IV.