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Supplemental Information

Disruption of Magnetic Compass Orientation in Migratory Birds by Radiofrequency Electromagnetic Fields

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SUPPLEMENTARY INFORMATION

Disruption of magnetic compass orientation in migratory birds by radiofrequency electromagnetic fields

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SUPPLEMENTARY FIGURES

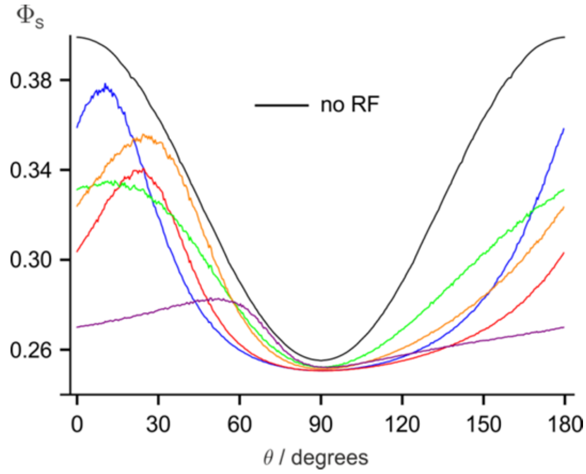

FIGURE S1.
FAD-Z radical pair with no exchange or dipolar interactions. The anisotropic singlet yield, $\Phi_S(\theta)$, calculated for five 0-10 MHz broadband fields (coloured lines); these differ because of the randomly assigned phase, direction and amplitude of each of the frequency components.

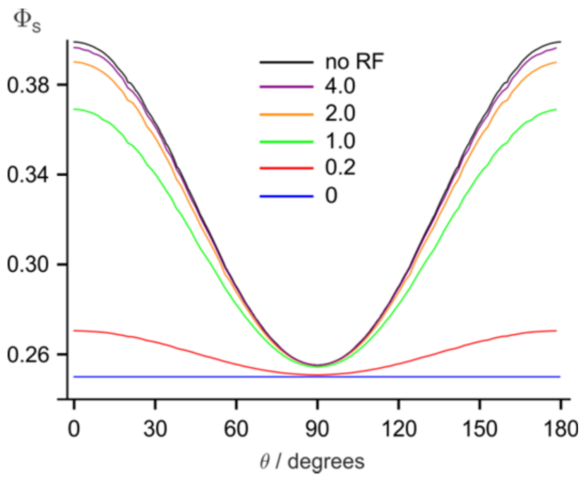

FIGURE S2.
FAD-Z radical pair with no exchange or dipolar interactions. The anisotropic singlet yield, $\Phi_S(\theta)$, in the presence of a single-frequency magnetic field with various frequency offsets from the Larmor frequency. The offsets, $\Delta\nu$, are given as multiples of $\gamma_e B_1 / 2\pi$.

SUPPLEMENTARY TABLE

TABLE S1.

Summary of behavioural experiments in which test animals were exposed to time-dependent magnetic fields. The Larmor frequency is given for the static field strength quoted in the study (column 3). The experimental conditions under which the animal could (column 4) and could not (column 5) magnetically orient are also shown. ν_L (or $n\nu_L$) in columns 4 and 5 indicates that a single-frequency field at the Larmor frequency (or a multiple thereof) was used; otherwise the frequency is given explicitly. A frequency range denotes a broadband noise condition. B_1 is the 'strength' of the radiofrequency field as given in the study. Where no B_1 is given, the study provides an intensity spectrum of the time-dependent field.

Study	Test animal	Larmor frequency (ν_L)	Oriented RF condition	Disoriented RF condition
Ritz *et al*. 2004	European robin	1.315 MHz	7 MHz (B_1 = 470 nT) parallel to static field	7 MHz (B_1 = 470 nT) oriented 24^o and 48^o to static field, 0.1–10 MHz (B_1 = 85 nT)
Thalau *et al*. 2005	European robin	1.315 MHz	ν_L (B_1 = 485 nT) parallel to static field	ν_L (B_1 = 485 nT) oriented 24^o to static field
Thalau *et al*. 2006	Ansell's mole rat	1.315 MHz	0.1-10 MHz (B_1 = 85 nT) and ν_L (B_1 = 4800 nT)	
Ritz *et al*. 2009	European robin	1.315 MHz and 2.63 MHz	ν = 0.5 ν_L and 2 ν_L (B_1 = 15 nT)	ν_L (B_1 = 15 nT) for static field strengths 47 µT, 94 µT
Keary *et al*. 2009	Zebra finch	1.204 MHz		1.156 MHz (B_1 = 470 nT) in 43 µT field
Vácha *et al*. 2009	American cockroach	1.2 MHz	7 MHz (B_1 = 44 nT)	ν_L (12 nT < B_1 < 18 nT); 2 ν_L (18 nT < B_1 < 44 nT)
Winklhofer *et al*. 2013	European robin	0.112 MHz		1.315 MHz (B_1 = 480 nT) in 4 µT field
Engels *et al*. 2014	European robin	1.363 MHz	Weak noise field control	20-450 kHz, 0.6-3 MHz, 2-9 MHz and background "electrosmog"
Kavokin *et al*. 2014	Garden warbler	1.4 MHz		ν_L (B_1 = 190 nT)
Wiltschko *et al*. 2015	European robin	1.315 MHz	No RF after pre-exposure to ν_L (B_1 = 15 nT)	7 MHz (B_1 = 480 nT) and ν_L (B_1 = 15 nT) after pre-exposure
Landler *et al*. 2015	Snapping turtle	1.43 MHz	Control group, ν_L (B_1 = 30–52 nT) after pre-exposure (opposite orientation to control)	Pre-exposed to RF, tested in absence of RF and vice versa. ν_L (B_1 = 30–52 nT)
Malkemper *et al*. 2015	Wood mouse	1.33 MHz	ν_L (B_1 = 785–1260 nT) same as control, 0.9-5.0 MHz (B_1 = 25-100 nT) shifted orientation by 90^o	
Schwarze *et al*. 2016	European robin	1.363 MHz	ν_L (B_1 = 48 nT)	2 kHz–9 MHz