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Supplementary Table 1. Cross-correlation rate between $^{13}C^{\alpha}$-$^{1}H^{\alpha}$ dipolar and $^{13}C'$ CSA interactions, $\Gamma_{H\alpha C\alpha,C'}$, for ubiquitin (2 mM, 50 mM potasium phosphate, pH 5.0, 30°C) recorded on a Varian Unity+ 500 MHz spectrometer.

Residue	$\Gamma_{H\alpha C\alpha,C'}$ (s^{-1}) (error)	$\Psi(°)$[a]
M1	-3.11(0.29)	149.6
Q2	-0.03(0.37)	138.3
I3	-4.27(0.44)	163.0
F4	-1.39(0.46)	140.2
V5	1.16(0.39)	114.2
K6	0.54(0.33)	127.5
T7	-5.00(0.30)	170.8
L8	-0.29(0.30)	-6.9
G10	-9.86(0.39)	16.5
K11	-1.73(0.27)	138.1
T12	1.39(0.34)	131.8
I13	-1.53(0.30)	142.0
T14	1.23(0.32)	139.7
L15	-2.16(0.30)	154.0
E16	1.91(0.36)	121.1
V17	-3.66(0.34)	170.7
P19	1.42(0.30)	-24.5
S20	-6.01(0.25)	-8.1
D21	0.29(0.36)	148.4
T22	-3.00(0.46)	160.4
E24	4.71(0.39)	-40.5
N25	2.76(0.34)	-44.4
V26	3.97(0.37)	-46.4
K27	4.86(0.40)	-38.0
A28	3.82(0.32)	-38.1
K29	3.32(0.37)	-37.3
I30	3.76(0.41)	-39.6
Q31	5.02(0.36)	-48.6
D32	3.18(0.26)	-41.8
K33	3.54(0.39)	-24.4
E34	-3.38(0.37)	-6.3
G35	-9.97(0.57)	5.3
P38	3.65(0.30)	-32.2
D39	-3.49(0.31)	-15.6
Q40	-4.79(0.36)	-10.5
Q41	1.09(0.46)	129.7
R42	-0.59(0.46)	116.0
L43	1.23(0.41)	130.2
I44	-0.77(0.47)	131.8
A46	-8.85(0.32)	46.0
G47	-10.80(0.51)	21.6
K48	-0.28(0.27)	142.7
Q49	1.36(0.43)	130.3
L50	1.32(0.38)	138.3
E51	0.01(0.50)	140.0

G53	-11.73(0.63)	-8.9
R54	-4.36(0.40)	165.5
T55	-3.56(0.40)	164.6
L56	4.77(0.34)	-36.2
S57	2.38(0.33)	-29.6
D58	0.83(0.43)	-39.3
Y59	-7.15(0.34)	4.7
N60	-10.05(0.38)	45.4
I61	0.30(0.32)	116.4
Q62	-4.74(0.29)	169.5
K63	0.59(0.41)	143.1
E64	-10.58(0.32)	19.1
S65	-3.72(0.31)	159.5
T66	1.08(0.43)	126.7
L67	-3.28(0.38)	154.6
H68	-0.33(0.45)	135.7
L69	0.20(0.44)	115.8
V70	-1.87(0.29)	139.9
L71	-0.22(0.30)	138.8
R72	0.38(0.20)	98.8
L73	-0.85(0.16)	150.4
R74	-0.22(0.15)	93.9
G75	-1.76(0.12)	125.6

[a]Calculated from x-ray structure. (Vijay-Kumar, S.; Bugg, C. E.; Cook, W. J. *J. Mol. Biol.* 1987, 194, 531).

Supplementary Table 2. Cross-correlation rate between $^{13}C^{\alpha}$-$^{1}H^{\alpha}$ dipolar and $^{13}C'$ CSA interactions, $\Gamma_{H\alpha C\alpha,C'}$, for CheY (1.8 mM, 5 mM $MgCl_2$, 0.1M phosphate buffer, pH 6.8, 30°C) recorded on a Varian Unity+ 500 MHz spectrometer.

Residue	$\Gamma_{H\alpha C\alpha,C'}$ (s^{-1}) (error)	$\Psi(°)^a$
D3	0.08(0.39)	125.0
K4	-8.82(0.54)	-16.6
E5	-13.02(0.53)	7.7
L6	0.03(0.75)	130.3
K7	2.57(1.40)	116.6
F8	-0.07(1.54)	143.2
L9	2.34(1.36)	118.0
V10	3.10(1.36)	121.4
V11	2.38(1.29)	117.2
T16	8.81(1.45)	-37.4
M17	6.92(1.69)	-35.8
R18	9.92(1.80)	-44.4
I20	9.94(1.29)	-48.6
V21	8.24(1.10)	-44.5
R22	7.49(1.08)	-41.4
N23	3.66(1.04)	-40.8
K26	8.63(0.92)	-46.8
E27	3.82(0.77)	-29.8
L28	-11.71(0.82)	-11.6
G29	-21.93(2.05)	12.5
F30	0.10(0.99)	99.4
N31	-8.04(0.80)	-8.1
N32	-3.14(0.83)	79.4
V33	1.70(1.06)	138.5
E34	-8.96(1.02)	160.0
E35	-3.56(1.21)	152.2
A36	-4.65(1.19)	149.3
E37	-6.51(1.03)	-24.7
G39	-15.78(3.30)	-44.2
V40	9.47(1.23)	-38.4
D41	9.14(0.86)	-45.8
A42	8.53(0.77)	-45.1
K45	8.22(1.08)	-39.3
A48	-5.23(0.55)	-15.3
G49	-29.00(3.32)	-179.8
G50	-21.80(1.80)	9.5
Y51	-1.09(1.76)	146.8
G52	-22.18(2.81)	-15.8
F53	-0.24(1.34)	136.7
V54	1.22(1.33)	135.2
S56	2.63(3.01)	141.4
P61	-3.45(1.35)	163.4
M63	2.33(2.06)	112.5

G65	-13.67(3.63)	-41.9
L66	7.30(0.97)	-41.3
E67	8.03(1.21)	-42.3
L68	13.04(1.79)	-48.0
L69	9.11(1.21)	-49.6
K70	8.08(1.05)	-37.7
T71	9.12(1.73)	-40.8
I72	10.91(1.59)	-43.9
R73	-1.82(1.07)	-32.6
D75	2.27(0.70)	121.5
G76	-14.82(1.30)	-40.7
A77	0.53(0.61)	-25.2
M78	-13.45(0.80)	-0.3
S79	1.10(0.62)	-18.9
A80	-13.86(0.57)	-8.0
P82	-0.24(1.33)	136.2
V83	4.23(1.63)	116.3
L84	1.45(2.99)	117.8
M85	0.96(2.12)	140.6
V86	0.65(1.66)	129.2
T87	-5.36(1.74)	155.8
A88	-3.29(0.60)	-11.7
K92	6.47(0.80)	-50.9
E93	4.20(0.71)	-29.4
N94	5.96(0.85)	-48.0
I95	8.19(1.02)	-46.1
I96	7.46(0.65)	-45.6
A97	8.34(0.70)	-42.6
A98	8.36(0.62)	-46.6
A99	8.70(0.76)	-51.0
Q100	2.68(0.55)	-34.3
A101	-10.59(0.77)	-2.4
G102	-21.07(2.23)	12.4
A103	0.42(0.97)	142.4
S104	0.34(0.97)	-26.7
G105	-28.31(4.12)	177.4
V107	-2.74(1.08)	136.2
V108	2.54(0.98)	132.6
P110	-0.39(1.02)	152.4
F111	-6.62(0.98)	156.4
T112	-8.60(0.72)	172.7
A113	7.31(0.58)	-42.0
A114	9.91(0.72)	-42.4
T115	8.21(0.77)	-46.4
E117	8.80(0.80)	-47.8
K119	8.77(0.88)	-43.3
L120	9.91(0.84)	-53.2
N121	6.85(0.66)	-41.6
K122	6.02(0.87)	-46.6
I123	9.37(0.92)	-47.6
F124	7.51(0.82)	-42.5
K126	3.81(0.67)	-33.4
L127	-9.59(0.57)	2.3
G128	-14.08(1.04)	48.7

[a]Calculated from x-ray structure (Stock, A. M.; Martinez-Hackert, E.; Rasmussen, B. F.; West, A. H.; Stock, J. B.; Ringe, D.; Petsko, G. A. *Biochemistry* 1994, 32, 13375).