

# Bibliography

1. Averbuch, A.Z., Neitaanmäki, P., Zheludev, V.A.: Spline and spline wavelet methods with applications to signal and image processing, Springer International Publishing, 2016
2. Bratelli, O., Jorgensen, P.: Wavelets Through a Looking Glass: The World of the Spectrum. Birkhauser, 2002
3. Cameron, P.J.: Permutation Groups, Cambridge University Press, 1999
4. Christensen, O.: An introduction to frames and Riesz bases. Birkhäuser, Boston (2003)
5. Christensen, O.: Frames and bases: an introductory course. Applied and Numerical Harmonic Analysis. Birkhäuser Boston Inc, Boston, MA (2008)
6. Christensen, O.: Frames and bases: An introductory course, Birkhauser, 2008
7. Chui, C.K.: An introduction to wavelets. Academic Press, New York (1992)
8. Daubechies, I.: Ten lectures on wavelets. SIAM, CBMS-NSR Series in Appl. Math (1992)
9. Dong, B., Shen, Z.: MRA-based wavelet frames and applications, Ser. 19, AMS, Providence, RI, 2013
10. Hernandez, E., Weis, G.A.: A first cours of wavalets. CRC Press, Boca Raton, FL (1996)
11. Kashin, B.S., Saakyan, A.A.: Orthogonal series. AMS, Providence, RI, Translations Mathematical Monographs **75**, (1999)
12. Mallat, S.: A wavelet tour of signal processing, 3rd edn. Academic Press, New York (2009)
13. Meyer, J.: Wavelets and operators, Lect. Notes Math. 1989. Vol.137
14. Meyer, Y.: Wavelets and operators, Cambridge University Press. Cambridge. 1992. (English translation of [15])
15. Wojtaszczyk, P.: A mathematical introduction to wavelets, London Math. Soc. Student texts **37**. 1997
16. Allen, J. D.: Perfect reconstruction filter banks for the hexagonal grid, in Fifth International Conference on Information, Communications and Signal Processing, 73–76 (2005)
17. Andaloro, G., Cotronei, M., Puccio, L.: A new class of non-separable symmetric wavelets for image processing. Communications to simai congress **3**, 324–336 (2009)
18. Ando, T., Shih, M.-H.: Simultaneous contractibility. SIAM J. Matrix Anal. Appl. **19**(2), 487–498 (1998)
19. Averbuch, A.Z., Zheludev, V.A., Cohen, T.: Multiwavelet frames in signal space originated from Hermite splines. IEEE Transactions on Signal Processing **55**(3), 797–808 (2007)
20. Battle, G.: A block spin construction of ondelettes. Part 1: Lemarier functions, Comm. Math Phys. **110**, 601–615 (1987)
21. Belogay, E., Wang, Y.: Arbitrarily smooth orthogonal non-separable wavelets in  $R^2$ . SIAM J Math Anal. **30**(3), 678–697 (1999)
22. Berger, M.A., Wang, Y.: Bounded semigroups of matrices. Linear Alg. Appl. **166**, 21–27 (1992)

23. Blondel, V.D., Tsitsiklis, J.N.: The boundedness of all products of a pair of matrices is undecidable. *Syst. Control Lett.* **41**(2), 135–140 (2000)
24. Blondel, V.D., Tsitsiklis, J.N.: Approximating the spectral radius of sets of matrices in the max-algebra is NP-hard. *IEEE Trans. Autom. Control* **45**(9), 1762–1765 (2000)
25. Blu, T., Unser, M., van de Ville, D.: On the multidimensional extension of the quincunx subsampling matrix. *IEEE Signal Processing Letters* **12**(2), 112–115 (2005)
26. de Boor, C., DeVore, R., Ron, A.: On construction of multivariate (pre) wavelets, *Constr. Approx.*, 123–166 (1993)
27. de Boor, C., DeVore, R., Ron, A.: The structure of finitely generated shift-invariant spaces in  $L_2(\mathbb{R}^d)$ . *J. Funct. Anal.* **119**(1), 37–78 (1994)
28. de Boor, C., DeVore, R., Ron, A.: Approximation from shift-invariant subspaces of  $L_2(\mathbb{R}^d)$ . *Trans. Am. Math. Soc.* **341**(2), 787–806 (1994)
29. de Boor, C., DeVore, R., Ron, A.: Approximation orders of FSI spaces in  $L_2(\mathbb{R}^d)$ . *Constructive Approximation* **14**(3), 411–427 (1998)
30. Bownik, M.: Tight frames of multidimensional wavelets. *J. Fourier Anal. Appl.* **3**, 525–542 (1997)
31. Bownik, M.: A Characterization of Affine Dual Frames in  $L_2(\mathbb{R}^n)$ . *Appl. Comput. Harmon. Anal.* **8**(2), 203–221 (2000)
32. Bownik, M., Weber, E.: Affine frames, GMRA's, and the canonical dual, *Studia Mathematica* **159**(3), 453–479 (2003)
33. Bownik, M., Rzeszutnik, Z.: On the existence of multiresolution analysis for framelets. *Math. Ann.* **332**, 705–720 (2005)
34. Bownik, M., Speegle, D.: The Feichtinger Conjecture for Wavelet Frames, Gabor Frames and Frames of Translates. *Canad. J. Math.* **58**(6), 1121–1143 (2006)
35. Bownik, M., Lemvig, J.: The canonical and alternate duals of a wavelet frame. *Appl. Comput. Harmon. Anal.* **23**(2), 263–272 (2007)
36. Charina, M., Chui, C.K.: Tight frames of compactly supported multivariate multi-wavelets. *Journal of Computational and Applied Mathematics* **233**(8), 2044–2061 (2010)
37. Chen, Di.-R., Han, H., Riemenschneider, S.D.: Construction of multivariate biorthogonal wavelets with arbitrary vanishing moments, *Adv. Comput. Math.* **13** (2000), no. 2, 131–165
38. Chui, C.K., Lian, J.: Construction of compactly supported symmetric and antisymmetric orthonormal wavelets with scale = 3. *Appl. Comput. Harmon. Anal.* **2**(1), 21–51 (1995)
39. Chui, C.K., He, W.: Compactly supported tight frames associated with refinable functions. *Appl. and Comp. Harm. Anal.* **8**, 293–319 (2000)
40. Chui, C.K., He, W.: Construction of multivariate tight frames via Kronecker products. *Appl. Comput. Harmon. Anal.* **11**, 305–312 (2001)
41. Chui, C.K., He, W., Stöckler, J.: Compactly supported tight and sibling frames with maximum vanishing moments. *Appl. Comput. Harmon. Anal.* **13**, 224–262 (2002)
42. Chui, C.K., Czaja, W., Maggioni, M., Weiss, G.: Characterization of General Tight Wavelet Frames with Matrix Dilations and Tightness Preserving Oversampling. *Journal of Fourier. Analysis and Applications* **8**(2), 173–200 (2002)
43. Cohen, A.: Ondelettes, analyses multirésolutions et filtres miroir en quadrature, *Ann inst. H. Poincaré, Anal. non linéaire*, **7** (1990), 439–459
44. Cohen, A., Daubechies, I., Feauveau, J.C.: Biorthogonal Bases of Compactly Supported Wavelets, pp. 485–560. *XLV, Communications on Pure and Applied Mathematics* (1992)
45. Cohen, A., Daubechies, I.: A stability criterion for biorthogonal wavelet bases and their related subband coding schemes. *Duke Math. J.* **68**, 313–335 (1992)
46. Cohen, A., Daubechies, I.: Nonseparable bi-dimensional wavelet bases, *Revista Mat. Iberoamericana* (I), 51–137 (1993)
47. Cohen, A., Dyn, N.: Nonstationary subdivision schemes and multiresolution analysis. *SIAM J. Math. Anal.* **27**, 1745–1769 (1996)
48. Cohen, A., Schlenker, J.-M.: Compactly supported bidimensional wavelet bases with hexagonal symmetry. *Constructive Approximation* **9**(2), 209–236 (1993)

49. Collela, D., Heil, C.: Dilation equations and the smoothness of compactly supported wavelets, in *Wavelets: Mathematics and applications.*, J. Benedetto, M. Frazier, eds., CRC Press, Bosa Raton, FL 1993, 161–200
50. Daubechies, I.: Orthonormal basis of compactly supported wavelets. *Comm. Pure Appl. Math.* **46**, 909–996 (1988)
51. Daubechies, I., Han, B., Ron, A., Shen, Z.: Framelets: MRA-based constructions of wavelet frames. *Appl. Comput. Harmon. Anal.* **14**(1), 1–46 (2003)
52. Daubechies, I., Han, B.: Pairs of dual wavelet frames from any two refinable functions. *Constr. Approx.* **20**(3), 325–352 (2004)
53. Daubechies, I., Lagarias, J.: Two-scale difference equations. I. Global regularity of solutions, *SIAM. J. Math. Anal.*, **22**, 1388–1410 (1991)
54. Daubechies, I., Lagarias, J.: Corrigendum/addendum to: Sets of matrices all infinite products of which converge. *Linear Alg. Appl.* **327**, 69–83 (2001)
55. Derfel, G.A., Dyn, N., Levin, D.: Generalized refinement equations and subdivision processes. *Journal of Approx. Theory* **80**, 272–297 (1995)
56. Deslauriers, G., Dubuc, S.: Symmetric iterative interpolation processes. *Constr. Approx.* **5**, 49–68 (1989)
57. Duffin, R.J., Schaeffer, A.S.: A class of nonharmonic Fourier series. *Trans. Amer. Math. Soc.* **72**, 341–366 (1952)
58. Dyn, N., Gregory, J.A., Levin, D.: Analysis of linear binary subdivision schemes for curve design. *Constr. Approx.* **7**, 127–147 (1991)
59. Dyn, N., Levin, D.: Interpolatory subdivision schemes for the generation of curves and surfaces, *Multivariate approximation and interpolation, 1990, (Duisburg 1989)*, 91–106
60. Dyn, N., Levin, D.: Subdivision schemes in geometric modelling. *Acta Numer.* **11**, 73–144 (2002)
61. Dyn, N., Skopina, M.: Decompositions of trigonometric polynomials with applications to multivariate subdivision schemes. *Advances in Computational Mathematics* **38**(2), 321–349 (2013)
62. Ehler, M., Han, B.: Wavelet bi-frames with few generators from multivariate refinable functions. *Appl. Comput. Harmon. Anal.* **25**(3), 407–414 (2008)
63. Ehler, M.: On multivariate compactly supported bi-frames. *J. Fourier Anal. Appl.* **13**(5), 511–532 (2007)
64. Ehler, M.: Compactly supported multivariate pairs of dual wavelet frames obtained by convolution, *Int. J. Wavelets, Multiresolut. Inf. Process.*, **6** (2008), no. 2, 183–208
65. Ehler, M., Koch, K.: The construction of multiwavelet bi-frames and applications to variational image denoising, *Int. J. Wavelets, Multiresolut. Inf. Process.*, **8** (2010), no. 3, 431–455
66. Entezari, A., Moller, T., Vaisey, J.: Subsampling matrices for wavelet decompositions on body centered cubic lattices. *IEEE Signal Processing Letters* **11**(9), 733–735 (2004)
67. Geronimo, J.S., Woerdeman, H.J.: Positive extensions. Fejér-Riesz factorization and autoregressive filters in two variables, *Annals of Mathematics* **160**(3), 839–906 (2004)
68. Goh, S.S., Lim, Z.Y., Shen, Z.: Symmetric and antisymmetric tight wavelet frames. *Appl. Comput. Harmon. Anal.* **20**, 411–421 (2006)
69. Gripenberg, G.: Computing the joint spectral radius. *Lin. Alg. Appl.* **234**, 43–60 (1996)
70. Gröchenig, K., Madych, W.R.: Multiresolution analysis, Haar bases and self-similar tilings of  $R^n$ . *IEEE Trans. Inform. Theory.* **38**, 556–568 (1992)
71. Gröchenig, K., Haas, A.: Self-similar lattice tilings. *J. Fourier Anal. Appl.* **2**, 131–170 (1994)
72. Guglielmi, N., Zennaro, M.: On the zero-stability of variable stepsize multistep methods: the spectral radius approach. *Numer. Math.* **88**, 445–458 (2001)
73. Guo, W., Lai, M.-J.: Box spline wavelet frames for image edge analysis. *SIAM Journal on Imaging Sciences* **6**(3), 1553–1578 (2013)
74. Fujinoki, K., Vasilyev, O.V.: *Triangular Wavelets: An Isotropic Image Representation with Hexagonal Symmetry.* *EURASIP Journal on Image and Video Processing* (2009). doi:[10.1155/2009/248581](https://doi.org/10.1155/2009/248581)
75. Haar, A.: Sur Theorie de orthogonalen Funktionensysteme. *Math. Ann.* **69**, 331–371 (1910)

76. Han, B.: On dual wavelet tight frames. *Appl. Comput. Harmon. Anal.* **4**, 380–413 (1997)
77. Han, B., Jia, R.Q.: Multivariate refinement equations and convergence of subdivision schemes. *SIAM J. Math. Anal.* **29**(5), 1177–1199 (1998)
78. Han, B.: Symmetric orthonormal scaling functions and wavelets with dilation factor 4. *Advances in Computational Mathematics* **8**(3), 221–247 (1998)
79. Han, B.: Analysis and construction of optimal multivariate biorthogonal wavelets with compact support. *SIAM J. Math. Anal.* **31**(2), 274–304 (1999)
80. Han, B., Jia, R.Q.: Optimal interpolatory subdivision schemes in multidimensional spaces. *SIAM Journal on Numerical Analysis* **36**(1), 105–124 (1999)
81. Han, B.: Construction of multivariate biorthogonal wavelets by CBC algorithm, *Wavelet analysis and multiresolution methods (Urbana-Champaign, IL, 1999)*, 105–143, *Lecture Notes in Pure and Appl. Math.*, 212, Dekker, New York, 2000
82. Han, B.: Symmetry property and construction of wavelets with a general dilation matrix. *Linear Alg. Appl.* **353**, 207–225 (2002)
83. Han, B., Jia, R.Q.: Quincunx fundamental refinable functions and Quincunx biorthogonal wavelets. *J. Math. Comp.* **71**(237), 165–196 (2002)
84. Han, B.: Compactly supported tight wavelet frames and orthonormal wavelets of exponential decay with a general dilation matrix. *J. Comput. Appl. Math.* **155**, 43–67 (2003)
85. Han, B.: Symmetric multivariate orthogonal refinable functions. *Appl. Comput. Harmon. Anal.* **17**, 277–292 (2004)
86. Han, B., Mo, Q.: Symmetric MRA tight wavelet frames with three generators and high vanishing moments. *Appl. Comput. Harmon. Anal.* **18**, 67–93 (2005)
87. Han, B.: Matrix extension with symmetry and applications to symmetric orthonormal complex M-wavelets. *J. Fourier Anal. Appl.* **15**, 684–705 (2009)
88. Han, B., Shen, Z.: Characterization of Sobolev spaces of arbitrary smoothness using nonstationary tight wavelet frames. *Israel J. Math.* **172**, 371–398 (2009)
89. Han, B.: Symmetric orthonormal complex wavelets with masks of arbitrarily high linear-phase moments and sum rules. *Adv. Comput. Math.* **32**, 209–237 (2010)
90. Han, B.: Pairs of frequency-based nonhomogeneous dual wavelet frames in the distribution space. *Appl. Comput. Harmon. Anal.* **29**(3), 330–353 (2010)
91. Han, B., Zhuang, X.S.: Matrix extension with symmetry and its application to symmetric orthonormal multiwavelets. *SIAM J. Math. Anal.* **42**, 2297–2317 (2010)
92. Han, B.: Symmetric orthogonal filters and wavelets with linear-phase moments. *J. Comput. Appl. Math.* **236**, 482–503 (2011)
93. Han, B.: Nonhomogeneous wavelet systems in high dimensions. *Springer Proceedings in Mathematics* **13**, 121–161 (2012)
94. Han, B.: Properties of Discrete Framelet Transforms. *Math. Model. Nat. Phenom.* **8**(1), 18–47 (2013)
95. Han, B.: Algorithm for constructing symmetric dual framelet filter banks. *Math. Comp.* **84**, 767–801 (2015)
96. Jetter, K., Zhou, D.X.: Order of linear approximation from shift invariant spaces. *Constr. Approx.* **11**(4), 423–438 (1995)
97. Jia, R.Q.: Refinable shift-invariant spaces: From splines to wavelets, [CA] Chui, C.K. (ed.) et al., *Approximation theory VIII. Vol. 2. Wavelets and multilevel approximation. Papers from the 8th Texas international conference, College Station, TX, USA, January 8–12, 1995.* Singapore: World Scientific. Ser. Approx. Decompos. **6**, 179–208 (1995)
98. Jia, R.Q.: Approximation properties of multivariate wavelets. *Math. Comp.* **67**, 647–655 (1998)
99. Jia, R.Q.: Convergence rates of cascade algorithms. *Proc. Amer. Math. Soc.* **131**, 1739–1749 (2003)
100. Jia, R.Q.: Approximation by quasi-projection operators in Besov spaces. *J. Approx. Theory* **162**(1), 186–200 (2010)
101. Jia, R.Q., Micchelli, C.A.: Using the refinement equations for the construction of pre-wavelets II: Powers of two, Curves and Surfaces (P.J. Laurent, A. Le M haut é and L.L. Schumaker, eds.), Academic Press, New York. 1991, 209–246

102. Jia, R.Q., Micchelli, C.A.: Using the refinement equations for the construction of pre-wavelets V: extensibility of trigonometric polynomials. *Computing* **48**, 61–72 (1992)
103. Jia, R.Q., Shen, Z.: Multiresolution and wavelets. *Proceedings of the Edinburgh Mathematical Society* **37**, 271–300 (1994)
104. Jia, R.Q., Wang, J.: Stability and linear independence associated with wavelet decomposition, *Proc.Amer.Math.Soc.*, **117**, 1115–1124 (1993)
105. Jiang, Q.T.: Orthogonal and Biorthogonal FIR Hexagonal Filter Banks With Sixfold Symmetry. *IEEE Transactions on Signal Processing* **56**(12), 5861–5873 (2008)
106. Jiang, Q.T.: FIR filter banks for hexagonal data processing. *IEEE Trans. Image Proc.* **17**, 1512–1521 (2008)
107. Jiang, Q.T.: Biorthogonal wavelets with 6-fold axial symmetry for hexagonal data and triangle surface multiresolution processing, *Int. J. Wavelets, Multiresolution Info. Proc.*, **9** (2011), no. 5, 773–812
108. Jiang, Q.T.: Bi-frames with 4-fold axial symmetry for quadrilateral surface multiresolution processing. *J. Comput. Appl. Math.* **234**(12), 3303–3325 (2010)
109. Jiang, Q.T., Pounds, D.K.: Highly symmetric bi-frames for triangle surface multiresolution processing. *Appl. Comput. Harmonic Anal.* **31**, 370–391 (2011)
110. Ji, H., Riemenschneider, S.D.: Shen Z. Multivariate compactly supported fundamental refinable functions, dual and biorthogonal wavelets, *Studies of Applied Mathematics* **102**, 173–204 (1999)
111. Karakaz'yan, S., Skopina, M., Tchobanou, M.: Symmetric multivariate wavelets, *Int. J. Wavelets, Mult. Inform. Proc.*, **7** (2009), no. 3, 1–28
112. Kashin, B.S., Kulikova, T.Yu.: A Note on the description of frames of general form. *Mathematical Notes* **72**, 281–284 (2002)
113. Koch, K.: Multivariate symmetric interpolating scaling vectors with duals. *J. of Fourier Anal. and Apps.* **15**, 1–30 (2009)
114. Kotelnikov, V.A.: On the transmission capacity of the ‘ether’ and of cables in electrical communications (in Russian), *Proceedings of the first All-Union Conference, Upravlenie svyazi, RKK*, 1933
115. Krivoshein, A.V.: On construction of multivariate symmetric MRA-based wavelets. *Appl. Comput. Harmon. Anal.* **36**(2), 215–238 (2014)
116. Krivoshein, A.: Multivariate symmetric refinable functions and function vectors, *Int. J. Wavelets Multiresolut. Inf. Process.*, **14** (2016). doi:[10.1142/S021969131650034X](https://doi.org/10.1142/S021969131650034X)
117. Krivoshein, A.: Symmetric Interpolatory dual wavelet frames, *St. Petersburg Math. J., Algebra i Analiz* **28** (2016), no. 3, 36–66 (in Russian); English translation in *St. Petersburg Math. J.* (to appear)
118. Krivoshein, A.V., Ogneva, M.A.: Symmetric orthogonal wavelets with dilation factor  $M=3$ . *J. of Math. Sciences* **194**, 667–677 (2013)
119. Krivoshein, A., Skopina, M.: Approximation by frame-like wavelet systems. *Appl. Comput. Harmon. Anal.* **31**, 410–428 (2011)
120. Krivoshein, A.V., Skopina, M.A.: Construction of multivariate frames using the polyphase method, *Matem. Zametki* **100** (2016), no. 3, 473–476 (in Russian); English translation in *Mathematical Notes*, **100** (2016), no. 3,
121. Lagarias, J.C., Wang, Y.: The finiteness conjecture for the generalized spectral radius. *Linear Alg. Appl.* **21**, 17–42 (1995)
122. Lai, M.-J., Petukhov, A.: Method of Virtual Components for Constructing Redundant Filter and Wavelet Frames. *Appl. and Comp. Harm. Anal.* **22**(3), 304–318 (2007)
123. Lai, M.-J., Stöcler, J.: Construction of multivariate compactly supported tight wavelet frames **21**, 324–348 (2006)
124. Lawton, W.: Necessary and sufficient conditions for constructing orthonormal wavelet bases. *Math. Phys.* **32**, 57–81 (1991)
125. Lawton, W.: Tight frames of compactly supported affine wavelets. *J. Math. Phys.* **31**, 1898–1901 (1990)

126. Lawton, W., Lee, S.N., Shen, Z.: Stability and orthonormality of multivariate refinable functions. *SIAM J. Math. Anal.* **28**(4), 999–1114 (1997)
127. Lawton, W.M.: Necessary and sufficient conditions for constructing orthonormal wavelets. *J. Math. Phys.* **32**, 57–61 (1991)
128. Lemarier, P.G., Meyer, Y.: Ondelettes et bases Hilbertiennes. *Rev. Math. Iber.* **2**, 1–18 (1987)
129. Madych, W.R.: Some elementary properties of multiresolution analysis – a tutorial in theory and applications, C.K. Chui ed. Academic Press, 1992, 259–294
130. Maesumi, M.: An efficient lower bound for the generalized spectral radius. *Linear Alg. Appl.* **240**, 1–7 (1996)
131. Maximenko, I.E.: Biorthogonality of multivariate refinable functions, in book “Voprosy sovremennoi teorii approksimatsii”, SPbGU Publishing, 2004, 132–145 (in Russian)
132. Maximenko, I.E., Skopina, M.A.: Multivariate Periodic Wavelets. *St. Petersburg Math. J.* **15**(2), 165–190 (2004)
133. Mallat, S.: Multiresolution approximation and wavelets. *Trans. AMS.* **315**, 69–88 (1989)
134. Mallat, S.: A theory of multiresolution signal decomposition: the wavelets representation. *IEEE Trans. Pattern Anal. Machine Intell* **11**, 674–693 (1989)
135. Mallat, S.: Multiresolution approximation and wavelets. *Trans. Amer. Math. Soc.* **315**, 69–88 (1989)
136. Meyer, Y.: Ondelettes and fonctions splines. *Seminaire EDP, Paris* (December (1986)
137. Meyer, Y.: Principe d’incertitude, bases hilbertiennes et algebres d’operateurs, *Seminaire Bourbaki*. 1985–1986. V. 38. no. 662
138. Micchelli, C.A., Prautzsch, H.: Uniform refinement of curves. *Linear Alg. Appl.* **114**(115), 841–870 (1989)
139. Moision, B.E., Orlitsky, A., Siegel, P.N.: On codes that avoid specified differences. *IEEE Trans. Inform. Theory* **47**(1), 433–442 (2001)
140. Möller, H.M., Sauer, T.: Multivariate refinable functions of high approximation order via quotient ideals of Laurent polynomials. *Adv. Comput. Math.* **20**(1–3), 205–228 (2004)
141. Packer, J.A., Rieffel, M.A.: Wavelet filter functions, Matrix completion problem, and projective modules over  $C(\mathbb{T}^n)$ . *J. Fourier. Anal. Appl.* **9**(3), 101–116 (2003)
142. Petukhov, A.: Explicit construction of framelets. *Appl. Comp. Harm. Anal.* **11**, 313–327 (2001)
143. Petukhov, A.: Symmetric framelets. *Constr. Approx.* **19**, 309–328 (2003)
144. Petukhov, A.: Construction of symmetric orthogonal bases of wavelets and tight wavelet frames with integer dilation factor. *Appl. Comput. Harmon. Anal.* **17**, 198–210 (2004)
145. Petukhov, A.: Explicit construction of framelets. *Appl. Comput. Harmon. Anal.* **11**, 313–327 (2006)
146. Protasov, V.Yu.: The joint spectral radius and invariant sets of linear operators. *Fundam. Prikl. Mat.* **2**, 205–231 (1996)
147. Protasov, V.Yu.: Fractal curves and their applications to wavelets, *Proceeding of the International Workshop on self-similar systems*, July 30 - August 7, 1998, pp. 120–125. Russia, Dubna (1999)
148. Protasov, V.Yu.: Refinement equations with nonnegative coefficients. *J. Fourier Anal. Appl.* **6**(6), 55–77 (2000)
149. Protasov, V.Yu.: A complete solution characterizing smooth refinable functions. *SIAM Journal of Math. Analysis* **31**(6), 1332–1350 (2000)
150. Protasov, V.Yu.: The stability of subdivision operator at its fixed point. *SIAM J. Math. Analysis* **33**(2), 448–460 (2001)
151. Protasov, V.Yu.: Refinement equations and corresponding linear operators, *Int. J. Wavelets, Mult. Inform. Proc.*, **4** (2004), no. 3, 461–474
152. Riemenschneider, S.D., Shen, Z.W.: Multidimensional interpolatory subdivision schemes. *SIAM J. Numer. Anal.* **34**(6), 2357–2381 (1997)
153. Riemenschneider, S.D., Shen, Z.W.: Construction of compactly supported biorthogonal wavelets in  $L_2(\mathbb{R}^s)$  I, *Physics and modern topics in mechanical and electrical engineering*. Scientific and Engineering Society Press, 1999, 201–206

154. Riemenschneider, S.D., Shen, Z.W.: Construction of compactly supported biorthogonal wavelets in  $L_2(\mathbb{R}^s)$  II, Wavelet applications signal and image Processing VII. Proceedings of SPIE. **3813**, 264–272 (1999)
155. Ron, A., Shen, Z.: Gramian analysis of affine bases and affine frames, in book: Approximation Theory VIII, V. 2: Wavelets (C.K. Chui and L. Schumaker, eds) World Scientific Publishing Co. Inc (Singapore), 1995, 375–382
156. Ron, A., Shen, Z.: Frame and stable bases for shift-invariant subspaces of  $L_2(\mathbb{R}^d)$ . *Canad. J. Math.* **47**(5), 1051–1094 (1995)
157. Ron, A., Shen, Z.: Affine systems in  $L_2(\mathbb{R}^d)$ : dual systems. *J. Fourier. Anal. Appl.* **3**, 617–637 (1997)
158. Ron, A., Shen, Z.: The Sobolev regularity of refinable functions. *J. Approx. Theory* **106**, 185–225 (2000)
159. San Antolin, A., Zalik, R.A.: Some Smooth Compactly Supported Tight Wavelet Frames with Vanishing Moments, *J. Fourier. Anal. Appl.*, to appear
160. San Antolin, A., Zalik, R.A.: Some smooth compactly supported tight framelets associated to the quincux matrix, *J. Mathematical Analysis and Applications*, to appear
161. Shannon, C.E.: Communication in the presence of noise. *Proc. of the IRE.* **37**, 10–21 (1949)
162. Shen, Z.: Extension of matrices with Laurent polynomial entries, Proceedings of the 15th IMACS World Congress on Scientific Computation Modeling and Applied Mathematics, Ashim Syclow eds. 1997, 57–61
163. Skopina, M.: Local convergence of Fourier series with respect to periodized wavelets. *J. Approx. Theory* **94**, 191–202 (1998)
164. Skopina, M.: Wavelet approximation of periodic functions. *J. Approx. Theory* **104**, 302–329 (2000)
165. Skopina, M.: Localization principle for wavelet expansions, Proceedings of the International Workshop (July 30 - August 7, 1998, Dubna, Russia), (JINR, E5-99-38, Dubna, 1999), 125–130
166. Skopina, M.: On Construction of Multivariate Wavelets with Vanishing Moments. *Appl. Comput. Harmon. Anal.* **20**(3), 375–390 (2006)
167. Skopina, M.: Tight wavelet frames. *Dokl. Ross. Akad. Nauk* **419**(1), 26–29 (2008)
168. Skopina, M.: On construction of multivariate wavelet frames. *Appl. Comput. Harmon. Anal.* **27**(1), 55–72 (2009)
169. Stanhill, D., Zeevi, Y.Y.: Two-Dimensional Orthogonal Filter Banks and Wavelets with Linear Phase. *IEEE Trans. on Sign. Proc.* **46**(1), 183–190 (1998)
170. Sweldens, W.: The Lifting Scheme: A Custom-Design Construction of Biorthogonal Wavelets. *Appl. Comput. Harmon. Anal.* **2**, 186–200 (1996)
171. Tay, D.B.H.: Analytical design of 3-D wavelet filter banks using the multivariate Bernstein polynomial. *IEE Proceedings - Vision Image and Signal Processing* **147**(2), 122–130 (2000)
172. Tchobanou, M.K.: Design and implementation of multidimensional multirate systems, Midwest Symposium on Circuits and Systems, **2** (2004), II, 541–544
173. Tchobanou, M.K.: Polynomial methods for multi-dimensional filter banks’ design, European Signal Processing Conference, (2015) art. no. 7075514
174. Unser, M., Chenouard, N., De Ville, D.V.: Steerable Pyramids and Tight Wavelet Frames in  $L_2(\mathbb{R}^d)$ . *IEEE TRANSACTIONS ON IMAGE PROCESSING* **20**(10), 2705–2721 (2011)
175. Weinmann, A.: Subdivision schemes with general dilation in the geometric and nonlinear setting. *Journal of Approximation Theory* **164**(1), 105–137 (2012)
176. Wellend, G.V., Lundberg, M.: Construction of compact p-wavelets. *Constr. Approx.* **9**, 347–370 (1993)
177. Yang, J., Li, S.: Smoothness of multivariate refinable functions with infinitely supported masks. *J. Approx. Theory* **162**(6), 1279–1293 (2010)
178. Zhuang, X.S.: Matrix extension with symmetry and construction of biorthogonal multi-wavelets with any integer dilation. *Appl. Comput. Harmon. Anal.* **33**, 159–181 (2012)
179. Zhou, D.X.: Stability of refinable functions, multiresolution analysis and Haar bases. *SIAM J. Math. Anal.* **27**(3), 891–904 (1996)

180. Zhou, D.X.: The p-norm joint spectral radius and its applications in wavelet analysis. International conference in wavelet analysis and its applications, AMS/IP Studies in Advanced Mathematics **25**, 305–326 (2002)
181. Zhou, D.X.: The p-norm joint spectral radius for even integers. Methods Appl. Anal. **5**, 39–54 (1998)



# Index

## A

Admissible numbers for symmetry group, 172  
Almost frame-like system, 133  
Almost Lipschitz function, 228  
Analysis operator, 13  
Appropriate dilation matrix for symmetry group, 162  
Appropriate symmetry center for symmetry group, 162  
Approximation order, 86  
Associated wavelet functions, 132  
Axial symmetry group, 164

## B

Bessel system, 3  
Box spline, 31, 47  
Bracket product, 20

## C

Cohen's compact set, 65  
Cohen's criterion, 64  
Congruent vectors, 15

## D

Daubechies mask, 117  
Dilation matrix, 19  
Dual frames, 10

## F

Frame, 8  
Frame bounds, 8  
Frame-like system, 133

Full (fourfold) symmetry group, 165

## H

Hexagonal (sixfold) symmetry group, 165  
Hexagonal abelian symmetry group, 165  
Hölder exponent, 210  
H-symmetric function, 161

## I

Isotropic matrix, 210, 216

## J

Joint spectral radius, 214, 220

## K

Kronecker product, 234

## L

Lawton's criterion, 71  
Lifting scheme, 190  
Linear-phase moments, 163  
 $L_p$  spectral radius, 230

## M

Mask, 27  
Matrix extension principle, 40  
MEP, 40, 90  
Modulus of continuity, 228  
MRA, 26  
MRA-based wavelet system, 32, 33  
Multiresolution analysis, 26

**O**

Orbit, 167

**P**

Parseval's frame, 8

Polyphase component, 41

Polyphase matrix, 42

P-radius, 230

**R**

Refinable function, 27

Refinable mask, 27

Refinement equation, 27

Resonance degree, 229

Riesz basis, 1

Riesz's lemma, 109

Riesz system, 1

**S**

Scaling function, 26

Self-similarity equation, 213

Self-similarity operator, 213

Set of digits, 15

Sets congruent modulo  $\mathbb{Z}^d$ , 17

Stabilizer, 167

Strang-Fix condition, 140

Sum rule, 93, 171, 212

Symmetric function, 162

Symmetric trigonometric polynomials, 162

Symmetry group, 161

Synthesis operator, 13

**T**

Tight frame, 8

Tile, 210

Tiling, 210

Transition matrix, 213

Transition operator, 49

**U**

Unconditional basis, 3

Unimodular matrix, 46

Unimodular row, 46

**V**

Vanishing moments, 85, 86

Vectors congruent modulo  $M$ , 15 $VM_\alpha$  property, 85 $VM^n$  property, 86**W**

Wavelet function, 32, 33, 40

Wavelet mask, 36, 40

Wavelet space, 32

Wiener's theorem, 28