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(*b*. St. Mihiel, France, 1595; *d*. Leiden, Netherlands, 8 December 1632)

mathematics.

Girard's birthplace is fixed only by the adjective *Samielois* that he often added to his name, an adjective the printers of St. Mihiel often applied to themselves in the seventeenth century. The city belonged at that time to the duchy of Lorraine. The exact date of Girard's birth is subject to dispute. That of his death is known from a note in the *Journal* of Constantijn Huygens for 9 December 1632. The place of death is only conjectured.

Girard was undoubtedly a member of the Reformed church, for in a polemic against Honorat du Meynier he accused the latter of injuring "those of the Reformed religion by calling them heretics." This explainswhy he settled—at an unknown date—in the Netherlands, the situation of Protestants being very precarious in Lorraine.

The respectful and laudatory tone in which he speaks of Willebrord Snell in his *Trigonomelry* leads one to suppose that Girard studied at Leiden. According to Johann Friedrich Gronovius, in his *éloge* of Jacob Golius, in 1616 Girard engaged in scientific correspondence with Golius, then twenty years old.

When Golius succeeded Snell at Leiden in 1629, Constantijn Huygens wrote to him to praise the knowledge of Girard (*vir stupendus*), particularly in the study of refraction. On 21 July of the same year Pierre Gassendi wrote from Brussels to Nicholas de Peiresc that he had dined at the camp before Boisle-Roi with "... Albert Girard, an engineer now at the camp." We thus know definitely that Girard was an engineer in the army of Frederick Henry of Nassau, prince of Orange; yet the only title that he gives himself in his works is that of mathematician.

The end of Girard's life was difficult. He complains, in his posthumously published edition of the works of Stevin, of living in a foreign country, without a patron, ruined, and burdened with a large family. His widow, in the dedication of this work, is more precise. She is poor, with eleven orphans to whom their father has left only his reputation of having faithfully served and having spent all his time on research on the most noble secrets of mathematics.

Girard's works include a translation from Flemish into French of Henry Hondius' treatise on fortifications (1625) and editions of the mathematical works of Samuel Marolois (1627–1630), of the *Arithmetic* of Simon Stevin (1625), and of Stevin's works (1634). He also prepared sine tables and a succinct treatise on trigonometry (1626; 1627; 2nd ed., 1629) and published a theoretical work, *Invention nouvelle en l'algèbre* (1629). Although in the preface to the trigonometric tables (1626) he promised that he would very soon present studies inspired by Pappus of Alexandria (plane and solid loci, inclinations, and determinations), no such work on these matters appeared. Likewise, his restoration of Euclid's porisms, which he stated he "hopes to present, having reinvented them," never appeared.

Contributions to the mathematical sciences are scattered throughout Girard's writings. It should be said at the outset that, always pressed for time and generally lacking space, he was very stingy with words and still more so with demonstrations; thus, he very often suggested more than he demonstrated. His notations were, in general, those of Stevin and François Viète. "who surpasses all his predecessors in algebra." He improved Stevin's writing of the radicals by proposing that the cube root be written not as but as (*Invention nouvelle*, 1629) but, like Stevin, favored fractional exponents. He had his own symbols for > and <, and in trigonometry he was one of the first to utilize incidentally—in several very clear tables—the abbreviations sin, tan, and sec for sine, tangent, and secant.

In spherical trigonometry, following Viète and like Willebrord Snell, but less clearly than Snell, Girard made use of the supplementary triangle. In geometry he generalized the concept of the plane polygon, distinguishing three types of quadrilaterals, eleven types of pentagons, and sixty-nine (there are seventy) types of hexagons (*Trigonométrie*, 1626). With the sides of a convex quadrilateral inscribed in a circle one can construct two other quadrilaterals inscribed in the same circle. Their six diagonals are equal in pairs. Girard declared that these quadrilaterals have an area equal to the product of the three distinct diagonals divided by twice the diameter of the circle.

Girard was the first to state publicly that the area of a spherical triangle is proportional to its spherical excess (*Invention nouvelle*). This theorem, stemming from the optical tradition of Witelo, was probably known by Regiomontanus and definitely known by Thomas Harriot-who, however, did not divulge it. Girard gave a proof of it that did not fully satisfy him and that he termed “a probable conclusion.” It was Bonaventura Cavalieri who furnished, independently, a better-founded demonstration (1632).

In arithmetic Girard took up Nicolas Chuquet’s expressions “million,” “billion,” “trillion,” and so on. He “explains radicals extremely close to certain numbers, such that if one attempted the same things with other numbers, it would not be without greatly increasing the number of characters” (*Arithmétique de … Stevin*, 1625), He gave, among various examples, Fibonacci’s series, the values 577/408 and 1393/985 for , and an approximation of . One should see in these an anticipation of continuous fractions. They are also similar to the approximation 355/113 obtained for π by Valentin Otho (1573) and by Adriaan Anthoniszoon (1586) and to the contemporary writings of Daniel Schwenter.

In the theory of numbers Girard translated books V and VI of Diophantus from Latin into French (*Arithmétique de é Stevin*). For this work he knew and utilized not only Guilielmus Xylander’s edition, as Stevin had for the first four books, but also that of Claude Gaspar Bachet de Méziriac (1621), which he cited several times. He gave fourteen right triangles in whole numbers whose sides differ from unity. For the largest the sides are on the order of 3×10^{10} (*ibid*. p. 629).

Girard stated the whole numbers that are sums of two squares and declared that certain numbers, such as seven, fifteen, and thirty-nine, are not decomposable into three squares; but he affirmed, as did Bachet, that all of them are decomposable into four squares (*ibid* p. 662). The first demonstration of this theorem was provided by Joseph Lagrange (1772). Girard also contributed to problems concerning sums of cubes by improving one of Viéte’s techniques (*ibid*., p. 676).

In algebra, as in the theory of numbers, Girard showed himself to be a brilliant disciple of Viéte, whose “specious logistic” he often employed but called “literal algebra.” In his study of incommensurables Girard generally followed Stevin and the tradition of book X of Euclid, but he gave a very clear rule for the extraction of the cube root of binomials. It was an improvement on the method of Rafael Bombelli and was, in turn, surpassed by that which Descartes formulated in 1640 (*Invention nouvelle*).

Unlike Harriot and Descartes, Girard never wrote an equation in which the second member was zero. He particularly favored the “alternating order,” in which the monomials, in order of decreasing degree, are alternately in the first member and the second member. That permitted him to express, without any difficulty with signs, the relations between the coefficients and the roots. In this regard he stated, after Peter Roth (1608) and before Descartes (1637), the fundamental algebraic theorem: “Every equation in algebra has as many solutions as the denominator of its largest quantity” (1629).

A restriction immediately follows this statement, but it is annulled soon after by the introduction of solutions which are “enveloped like those which have ”. From this point of view, Girard hardly surpassed Bombelli, his rare examples treating only equations of the third and fourth degrees. For him the introduction of imaginary roots was essentially for the generality and elegance of the formulas. In addition, Girard gave the expression for the sums of squares, cubes, and fourth powers of roots as a function of the coefficients (Newton’s formulas).

Above all, Girard thoroughly studied cubic and biquadratic equations. He knew how to form the discriminant of the equations $x^3 = px + q$, $x^3 = px^2 + q$, and $x^4 = px^3 + q$. These are examples of the “determinations” that he had promised in 1626. The first equation is of the type solved by Niccolò Tartaglia and Girolamo Cardano, the second relates to book II of the *Sphere* of Archimedes, and the third to Plato’s problem in the *Meno*, With the aid of trigonometric tables Girard solved equations of the third degree having three real roots. For those having only one root he indicated, beside Cardano’s rules, an elegant method of numerical solution by means of trigonometric tables and iteration. He constructed equations of the first type geometrically by reducing them, as Viète did, to the trisection of an arc of a circle. This trisection was carried out by using a hyperbola, as Pappus had done. The figure then made evident the three roots of the equation.

Girard was the first to point out the geometric significance of the negative numbers: “The negative solution is explained in geometry by moving backward, and the minus sign moves back when the + advances. “To illustrate this affirmation he took from Pappus a problem of intercalation that Descartes later treated in an entirely different spirit (1637). This problem led him to an equation of the fourth degree. The numerical case that he had chosen admitted two positive roots and two negative roots; he made the latter explicit and showed their significance.

BIBLIOGRAPHY

I. Original Works. Girard’s two books are *Tables des sinus, tangentes et sécantes selon le raid de 100,000 parties*... (The Hague, 1626: 1627; 2nd ed., 1629), which also appeared in Flemish but had the Latin title *Tabulae sinuum tangentium et secantium ad radium 100,000* (The Hague, 1626; 1629); and *Invention nouvelle en l’algèbre* (Amsterdam, 1629; repr. Leiden, 1884). The repr. of the laner, by D. Bierens de Haan, is a faithful facs., except for the notation of the exponents, in which parentheses are substituted for the circles used by Girard and Stevin. However, the parentheses had been used by Girard in the *Tables*.

Girard was also responsible for trans. and eds. of works by others: *Oeuvres de Henry Hondius* (The Hague, 1625), which he translated from the Flemish; Samuel Marolois’s *Fortification ou architecture militaire* (Amsterdam, 1627), which he enlarged

and revised, and also issued in Flemish as *Samuel Maroloys Fortification...* (Amsterdam, 1627), and *Géométrie contenant la theorie et practique d'icelle. necessaire à la Fortification...* 2 vols. (Ansterdam, 1627–1628; 1629), which he revised and also issued in Flemish as *Opera mathematica ofte wis-konstige, Wercken—beschreven door Sam. Marolois —* (Amsterdam, 1630); and Simon Slevin's *L'arithmetique* (Leiden, 1625), which he revised and enlarged, and *Les oeuvres mathématiques de Simon Stevin* (Leiden, 1634), also revised and enlarged.

II. Secondary Literature. On Girard or his work, see several articles by Henri Bosmans in *Mathesis*, **40** and **41** (1926); Antonio Favaro, "Notizie storiche sulle frazioni continue," *in Bullettino di bibliografia e di storia delle scienze mateniatiche e fisiche*, 7 (1874), 533–596, see 559–565: Gino Loria, *Storia delle matematiche*, 2nd ed. (Milan. 1950), pp. 439–444; Georges Maupin, "Étude sur les annotations jointes par Albert Girard Samielois aux oeuvres mathématiques de Simon Stevin de Bruges," in *Opinions et curiosités iouchant le mathématiques* II (Paris, 1902), 159–325; Paul Tannery, "Albert Girard de Saint-Mihiel," in *Bulletin des sciences mathématiques et astronomiques,* 2nd ser.,**7** (1883), 358–360, also in Tannery's *Mémoires scientifiques*, VI (Paris. 1926), 19–22; and G. A. Vosterman van Oijen, "Quelques arpenteurs hollandais de la fin du XVI[eme] et du commencement du XVII[eme] siècle," in *Bullettino di bibliografia e di storia delle scienze matematiche e fisiche*, 3 (1870), 323–376, see 359–362.

See also *Nieuw Nederlandsch Woordenboek*, II (1912), cols. 477–481.

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