"O ye men of Galilee" — The Church and the Copernican Heresy

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Amid the miles of decaying manuscripts, carefully sewn into thick volumes and stuffed into the archival shelves of the Sacred Congregation for the Doctrine of the Faith, all sorted and numbered, stamped and sealed, signed and witnessed, is one peculiarly haphazard document. Its contents suggest that it is the minutes of a judicial proceeding, but it lacks a notary signature, as well as the signatures of witnesses who were supposedly present, and of the participants. Unlike every other document in this file, it does not begin on a fresh page, but is scrawled on the blank reverse of two other official documents. This is no ordinary scribal bungling, for this is no ordinary document, and it sits in no ordinary archive. Until recently this was the most secret archive in the world, storing under perpetual seal the records of an organization more clandestine than any Cold War spy agency, the Vatican bureau which until 1965 was called The Sacred Congregation of the Holy Office, itself founded in 1542 to take over the work of the medieval Congregation of the Supreme and Universal Inquisition. Conceived to crush the sparks of heresy flaring up throughout Europe, and revived in the 16th century to beat back the Protestant apostasy, the Inquisition could hardly have been accused of carelessness, or of indifference to legal niceties.

A lapse or two over several centuries of activity might be generously overlooked. But this document has a central role in an affair that makes all modern-day "trials of the century" seem like mere parking violations by comparison, an affair whose outcome would define the relationship between the rising power of scientific rationalism and the declining Christian theocracy up until our own century. It testifies to a meeting, which took place on February 26, 1616 in the official residence of Lord Cardinal Roberto Bellarmino, the Paradiso Rooms of the Vatican Palace. There, we may read, the Commissary General of the Holy Office ordered "the mathematician Galileo [...] to abandon completely the opinion that the sun stands still at the center of the world and the earth moves, and henceforth not to hold, teach, or defend it in any way whatever, whether orally or in writing."

The source of this dispute seems almost a parody of petty medieval philosophical preoccupations. Among the thousands of stars that a naïve observer sees in the night sky, there are a few — five have been known since antiquity — which glide among the others. (The other stars spin as a unit overhead.) These five exceptional celestial objects, and the sun and moon as well, were called by the ancient Greeks "wanderers" – in Greek, *planetes*. They had individual names as well, for the willful celestial motions were so suggestive of the pre-

rogatives of deities, that each planet was identified with a major divinity. The names of Roman gods — Mercury, Venus, Mars, Jupiter, and Saturn — have been maintained to the present day.

Careful observation revealed the motions to be essentially repetitive, and yet at the same time bizarrely idiosyncratic. While Venus wobbles back and forth in close proximity to the sun – now appearing behind the sun as the "morning star", now behind it as "evening star" – Mars drifts one way, then trips back for a few weeks, before looping around into its original course. Greek philosophy, in particular as it was crystallized in the works of Aristotle, wanted the heavens to be perfect and unchangeable, so all celestial motions should reflect the one perfect form, the circle. How could these strange planetary vagrancies be explained, and how could the future positions of these bodies best be predicted?

Even today, when space flight is a practical reality, and when we know the planets to be other worlds, which we are beginning to explore, which we have seen up close in photographs, it is hard to formulate hardheaded reasons for studying the planets. Why, then, did the most gifted thinkers devote vast intellectual and economic resources over millennia to minute examination and explanation of these few vagrant stars? The calendar was one reason. The largest "planet", the sun, passes from north to south across the sky and back again in a slow steady rhythm, determining the progress of the seasons. If the calendar is not precisely matched to this annual motion, the planting and harvest times will begin to slide confusingly through the year. The cycle of the moon is likewise essential, because it determines the dates of many religious festivals. In particular, Christian Europe was concerned with the problem of predicting the date of Easter, which depends upon both solar and lunar events. Solar eclipses, too, could be predicted by unraveling the tangled motions of sun and moon. So there developed over fourteen centuries a system of crystalline spheres within spheres, all dancing in circles about the earth once a day. The sheer force of the planets' love of God whirled them at breathtaking speeds in their effort to come closer to him.

In the Renaissance there was a different, overriding reason for studying the planets: astrology. It was the Greeks of about the second century BC who first systematized the notion that the motions of stars and planets determine or parallel the details of human affairs. It is not an implausible idea, really, if you think that the Earth is at the center of this cosmic whirligig; and with this idea the dull tables of planetary positions becomes a palimpsest, underneath which the future of kings and empires is written. After being condemned as unchristian superstition through the Middle Ages, astrology — then called "judicial astrology" — came roaring back with the revival of classical learning which we call the Renaissance. What we would today call astronomy, concerned with predicting the motions of celestial bodies was only a branch of astrology, then called "natural astrology". There was no clear distinction between the two, except that the former was disreputable, and far better paid.

It was this basic assumption that Nicholas Copernicus challenged in his magnum opus *De revolutionibus orbium coelestium*, published in 1543. His argument

was quite simple: The oppressively complicated computations of celestial motions become far more straightforward under the assumption that the sun, not the earth, is at the center of the universe, and that the earth was one of the planets circling about the sun. The stars are no longer rushing about, but are now immovable, in Copernicus' "heliocentric" (sun-centered) model, and seem to turn only because of a daily rotation of the earth itself.

Arguments for a rotating earth had been known since antiquity, carefully analyzed, and dismissed, with overwhelming physical and astronomical evidence. We see the sun and the stars spinning overhead on their daily rounds, and see the earth around us standing still. We know what it feels like to be in motion, and it certainly does not feel like we and the earth are constantly rushing around as fast as 1000 miles per hour. What would happen on a moving earth to a ball tossed straight up into the air? It could never land near its starting point, since the earth would spin away at a ferocious speed while the ball was aloft. What force could possibly keep the entire earth whirling about on its gigantic solar orbit? We know that it requires constant pushing to keep an object in motion, otherwise it grinds to a halt; the larger the object, the larger the required push. Most conclusively: Why had millennia of astronomical observation failed to detect this enormously rapid motion?

Still, no one expected a model of the heavens to make good physical sense. The purpose was to aid computations, and to this end many astronomers were willing to accept the new model in the same spirit in which they had admitted the old, without scratching their heads over how the rigid spheres carrying the planets could turn through one another with ease. Within a decade, Copernicus's ideas were already being applied to compute the first complete new set of astronomical tables in Europe in three hundred years. This practical success contributed more than any mathematical harmonies or scholastic syllogisms to elevating the reputation of Copernicus and his theories among the people who computed celestial motions for a living.

To the vast majority of their contemporaries, though, to whom earthly matters were the more present, the notion of a moving earth was so perverse as to appear nearly diabolical. It was, said Martin Luther, in his Table Talk of June 4, 1539, as if someone seated on a moving wagon or ship would propose that he were in fact at rest, and the entire earth and all the trees were in motion. Nowadays, anyone who wants to seem clever refuses to accept anything that other people do, he has to do it his own way, so that his way will be the absolute best. Fools want to turn around the whole field of astronomy." This influential ridicule came four years before the publication of *De revolutionibus*, and was soon followed by condemnations from most of the leaders of the Protestant reformation.

This conflict was exacerbated by one further argument of Luther: "As Holy Writ tells us, Joshua told the Sun to stand still, not the Earth." The argument was hardly profound, nor was it theologically very compelling. A long tradition of Christian Bible exegesis, going back at least to the venerable Church father Augustine, had accepted that such passages needed to be reinterpreted in the light of the best scientific understanding. The Bible, wrote Augustine in the

4th century, is silent on most questions about the form and structure of the universe. "The Spirit of God which spoke through [the evangelists] did not wish to teach things which contribute nothing to salvation." God "willed to make them Christians, not mathematicians." Or, as the 16th century Cardinal Baronius wittily summarized it, "The Holy Ghost intended to teach us how to go to heaven, not how the heavens go." But even as the good cardinal wrote these words, such splendid otherworldliness already had come to seem as old-fashioned as the papal tiara. A vast religious struggle was engulfing the European continent, and in the attendant theological arms race no weapon was too crude, or too unconventional. Biblical fundamentalism was by no means the most shameless ploy of a Church desperate to prove itself the one rightful guardian of the Christian heritage.

Monastic intrigues and theological squabbles were very far from the concerns of the Florentine patrician Galileo Galilei when he first turned his gaze to the stars. Until 1610, as a mathematics professor at the Venetian university of Padua, if he was known for anything it was as an inventor of gadgets, such as the Geometric-Military Compass, a sort of mechanical computer with everything an artillery engineer would need in a convenient package. But in 1610 he became at a stroke the most famous scientist in Europe. His radically improved design for the telescope — invented two years earlier by a Dutch spectacle maker — enabled him to discover four moons of Jupiter, which he bestowed on the Grand Duke of Florence Cosimo di Medici, calling them the "Medicean stars". Galileo was duly appointed "First mathematician and philosopher" to the Duke, and professor of mathematics in Pisa with no teaching duties. Some friends warned him that it might not be wise to abandon the free republic of Venice for a ducal court. There he would be subject to a ruler's whims and to the intrigues of the Jesuits, whose scheming had gotten them expelled from Venice several years earlier. But after 18 years in exile, Galileo longed to go home. The heavenly bodies were his ticket.

The great Jesuit astronomer Father Christopher Clavius confirmed Galileo's discoveries, and invited him to Rome. This visit, in the spring of 1611, was to be his greatest public triumph. Skeptics there were, but they were swept away by Galileo's charm, and the Medici court mathematician was the celebrity of the season in Rome. He brought with him not only his telescope, but also exciting new discoveries: the rings of Saturn (visible at that time only as a line bisecting the planet's disc) and the phases of Venus. This latter was to prove fateful indeed. If Copernicus were correct, the inner planets, Mercury and Venus, must show phases, like the moon, now full, now crescent, as their orientation with respect to the sun and earth changes. As these had never been observed, this was a forceful refutation of the heliocentric model. Now, with the telescope, such phases could indeed be seen. This was the first physical evidence that the Copernican system might really be true, not as a mathematical abstraction, but as a description of real motions. The moons of Jupiter had shown that it was indeed possible for planets to orbit something other than the earth; now Venus displayed its motion around the sun directly, to anyone willing to see it.

Most were not willing. After his triumph in Rome, Galileo resumed his

research and publication on scientific matters, but also found himself drawn into the dangerous waters of theological speculation. The more conservative Jesuit scientists found Copernican speculations just as unpalatable as Martin Luther eighty years earlier, and their resentment against Galileo's supposed proofs buzzed dangerously underground. The Copernican doctrine was a dangerous heresy, they said, contradicting the Bible and common reason. In an attempt to confront these machinations and drive them into the open, Galileo wrote an essay, in the form of a letter but meant to be copied and made public, on the need to separate science from theology. God, he wrote, has given us two books in which his will may be read: the Bible, and the book of nature. We need have no fear that the study of one book may contradict the other; where we imagine a contradiction, this is only a proof that we have inadequately understood one or the other. Catholic tradition had long recognized that certain passages of the Bible would themselves be absurd or heretical if understood literally, and he pointed out that the infamous "sun stand still" story in Joshua is equally incompatible with the Ptolemeic system. If the Copernican model seems, then, to contradict our interpretation of the Bible, that is all the more reason to give it careful consideration, so that we may come to a better understanding of the Bible itself. For a theologian — even the pope himself — to claim authority in scientific matters is as absurd, he wrote, as if a king by virtue of his absolute power were to issue decrees on medical matters, and insist that all patients in the realm be treated accordingly.

From the perspective of several centuries Galileo's polemic seems brilliant, even prescient, but the Church authorities of his time would have none of it. What is more, now that Galileo had stated clear views on theological matters, his enemies thought they had the rock on which to crush him. A Dominican denounced Galileo from the pulpit of Santa Maria Novella in Florence. In a wordplay on Galileo's name, he based his sermon on the Bible text "O ye men of Galilee, why do you stand gazing at the heavens?" Shortly thereafter another Dominican voiced grave concerns about heretical tendencies in the new learning in a secret letter to the Holy Office of the Inquisition. Sensing the knives being whetted for him in the Roman shadows, Galileo saddled up his mule and set out in person for the Eternal City.

Once there, though, there was little he could do. The Rome of 1616 was "no fit place to argue about the Moon or [...] to try and bring in new ideas," as the Florentine ambassador, compelled by his prince to host Galileo, unsympathetically wrote. The villas and monasteries seethed with gossip, spies and *agents provocateurs* of every ecclesiastical stripe roamed the crooked alleys of the medieval city, which even then was being razed and rebuilt in the monumental style favored by the Borghese pope Paul V. In fact, there was nothing that Galileo could do to save his Church from falling into deep and shameful error. While he was entertaining Roman society with his passionate scientific polemics, a commission of the Inquisition met in secret to consider two propositions: First, that "The Sun is the center of the world and hence immovable"; and second, that "The Earth is not the center of the world, nor immovable". The first was unanimously declared to be "foolish and absurd, philosophically

and formally heretical," while the second was, more mildly, "to receive the same censure in philosophy and, as regards philosophical truth, to be at least erroneous in faith". The works of Copernicus were ordered withdrawn until they could be "corrected", to more clearly emphasize the hypothetical mathematical (and not physically real) nature of the heliocentric model.

It is at this point that the mysterious document enters the story. Galileo was summoned to appear before Cardinal Bellarmino to be admonished, by command of the pope, to abandon the Copernican heresy. In the event that Galileo should refuse, the Commissary of the Holy Office was supposed to raise the pressure, issuing a command that he "abstain altogether from teaching or defending this position and doctrine and even from discussing it." In the event, though, Galileo demurred before the might of the Holy Office. And yet, there is this second protocol: unsigned, out of place, and yet still in the official record. Was it a forgery? Was the Dominican Commissary livid to see the heretic Galileo escape with a slap on the wrist, so that he leaped up to deliver the pope's stern injunction despite Galileo's acquiescence? This would be only an idle curiosity were it not for the central role that this document would play in the second act of the drama.

In 1621 died three of the central figures from the affair of 1616: Cardinal Bellarmino, Pope Paul V, and Galileo's patron Cossimo II Medici. The next pope reigned for only two years, and was succeeded in turn by Galileo's friend and supporter, Maffeo Barberini, who reigned as Pope Urban VIII. Barberini was a well-educated Florentine Jesuit who had defended Galileo through the troubles of 1616, and who three years later had gone so far as to pen "Dangerous Adulation", an encomium to the great scientist. The new pope let it be known that Galileo's new book, a devastating attack on a Jesuit scientist's theory of comets, was his favorite reading. Summoned to Rome for a series of long and adulatory audiences, Galileo left bearing gold and silver medals, and a host of rich presents from his papal admirer.

Despite this good will, the new pope was unwilling to revoke the censure of 1616, or to permit the Copernican theory once again to be freely taught. What would he allow then? Galileo tried to plumb his intentions, but seems to have received only ambiguous answers. Urban was convinced that scientific knowledge could never lead to certainty: surely, he argued, one cannot reason from the appearance of the world to a determination of the world's true workings. After all, God is all powerful, and could have made the world appear exactly so and yet function in an entirely inscrutable fashion, for reasons that no human being could fathom. Who can claim to know the mind of God? Galileo knew this argument, really an old chestnut of medieval philosophy warmed over, and expressed his contempt for it elsewhere, when he wrote, "Surely, God could have caused birds to fly with their bones made of solid gold, with their veins full of quicksilver, with their flesh heavier than lead, and with wings exceeding small. He did not, and that ought to show something. It is only in order to shield your ignorance that you put the Lord at every turn to the refuge of a miracle." But now he acquiesced, for he saw in Urban's relativism some breathing space: if he were willing ostentatiously to acknowledge the unproven and hypothetical

nature of his science, he could write whatever he chose. At least, that seems to have been his understanding.

Galileo pushed this slender compromise far beyond the breaking point. The summa of his studies, the Dialogue on the Two Chief World Systems, which he completed in 1630, was not only a scientific masterpiece, demolishing the decadent structures of medieval physics and astronomy to lay the groundwork for a potent new science; it was also a masterpiece of irony. The spirit of the writing is well expressed in a letter that Galileo wrote around the time he began the work. There we find a resolute defense of the Copernican theory on astronomical grounds, preceded by an almost absurd gesture of submission: I am not defending Copernicus because I think his theory true, writes Galileo, but rather to prove to the heretics of the north that Catholic Italy had not rejected Copernicus out of ignorance, but out of love of the divine truth. The more valid the scientific proofs, he writes further — and here one senses a nudge and a wink — the clearer the conclusion that the higher truth of the universe may not be found in science, but only in the bosom of the Church. While Galileo's adversaries in the universities and the Church were perhaps a bit intellectually rigid, even blinkered, they were not stupid, certainly not too stupid to know when they were being mocked. It would not be long before the knives were out again.

The work is in the form of a Socratic dialogue among three friends, who meet in a palazzo to discuss the new science: Salviati, who is Galileo's mouthpiece; Sagredo, the reader's surrogate, as yet unlearned, but clever and curious and quick to recognize the wisdom of Salviati's teaching; and Simplicio, as simple-minded as his name suggests, who represents the old learning. It is a marvel of Italian prose, by turns arch and profound, which smashes, unlocks, and tunnels through the mental prison of Aristotelian concepts. The arguments are at once pellucid and workaday, appealing to the logic of ingenious thought experiments and the irresistable evidence of Galileo's own workshop experiments, and to his telescopic observations. Above all, this is a work that demands self-reliance and liberty. Who will be our guide, asks Simplicio, if we reject Aristotle? "A guide is needed only when crossing unknown wilderness," retorts Salviati. "In open country only blind men need their protection. Those who are blind might in any case best stay home. But those who have eyes, physical and mental, should take these as their guide."

Unfortunately, Galileo was less successful in proving the case for his new science than he was in demolishing the old. Much more solid evidence, in the form of the laws of planetary motion derived by his contemporary Johannes Kepler, sat on Galileo's bookshelf unread, owing perhaps to Galileo's distaste for the German's mystical airs. In retrospect, knowing that the Catholic Church would not lift the ban on Copernicus' work for another two centuries, we may be certain that no evidence that Galileo could have brought would have persuaded his ecclesiastical opponents. At the same time, Galileo did not help his cause by appending to his overwhelming defense of the Copernican theory a ridiculous little exchange in which the dunce Simplicio, thoroughly trounced at every turn, now pipes up with the pope's favorite argument, that God could have made the

world appear so and still be otherwise. Salviati praises this "angelic" insight, and so ends the dialogue. It is hardly surprising that the pope felt he was being lampooned.

Still, Galileo had committed no crime in writing this treatise, and publication would be possible only with the imprimatur of the Inquisition. In fact, the Dialogue might never have passed the censor in Rome. As it happened, the plague intervened, and quarantine impeded travel throughout Italy. Galileo was given permission to submit his text to the Inquisition in Florence, where it passed with a far more perfunctory reading than it would have received in Rome.

The first printed copies reached the public in February of 1632, with a dedication to the Most Serene Master, Pope Urban VIII, and were showered with praise. Within six months, though, the political weather had shifted. Quarantine had delayed the book's arrival in Rome, but when the Pope did receive it he exploded, with the righteous fury of trust betrayed, exacerbated by the knowledge that he had confounded himself. All unsold copies were ordered confiscated, and Galileo himself was to appear in Rome forthwith. When the Tuscan ambassador responded that the scientist was too sick to make the trip — it was by now already well on into fall, the plague was abroad in the land, and Galileo was nearing his seventieth birthday — Urban replied that his only choice was whether he would come as a free man or in irons.

So Galileo set out, in late January, carried slowly in a sedan chair; he made long pauses, but his arrival in Rome could not be postponed forever. The journey of about 100 miles lasted three weeks, and by dispensation of the holy office the prisoner was delivered into the ministrations of the Florentine embassy, rather than an Inquisition dungeon, as was the standard procedure. Amazingly, the evidence of his letters, and those of the ambassador, is that the septuagenarian scientist was preparing to fight back. The new ambassador, while a friend, could only advise him that Inquisition trials were not a venue to argue physical theories. He would be summoned when the case had been decided, and he would have only to submit.

On the other side, though, the church authorities were clearly off balance. Despite the reputation derived from its worst excesses, the Inquisition, particularly as instantiated in Rome, was neither lawless nor arbitrary. For its time, the devotion to formally correct procedure and rules of evidence was exemplary. Even when His Eminence himself, together with influential cardinals and professors, demanded Galileo's punishment, canon law remained sacrosanct. Had Galileo published a heretical book? But it had appeared under the imprimatur of the Holy Office. Had he ridiculed the pope's favored scientific theories? But this was no crime, at worst an insolence which required apology and revision of the text. Had he taught and defended the forbidden Copernican theory as fact? This would be difficult to prove, behind the text's sly disclaimers.

At this uncomfortable juncture the clerical bureaucrats opportunely discovered — some maintain that they invented — the Commissary's injunction of 1616. This solved their nice difficulties at a stroke: If Galileo had been formally commanded "not even to discuss" the heliocentric theory, then he was provably

defiant, and subject to the gravest punishment. It was a thin legal reed, but it would suffice. Those accused by the Inquisition were not even told the charges against them, much less allowed to review the evidence. Galileo never was told what the injunction was that he was supposed to have violated, which made it easy for the interrogators to lead him into contradictions. It hardly mattered. The sentence would never need to be defended in public. Still, the Holy Office was divided. The pope would not accept a lenient sentence. Galileo, now a prisoner of the Inquisition, was questioned again, but still refused to admit to having defended the heliocentric theory or having deceived the censor. He was at this point formally threatened with torture, an important part of the myth that would grow around this trial, although it was well known that torture was forbidden for a defendant of his age and poor health.

And so, at last, judgment was pronounced, and Galileo was compelled ceremonially to abjure the insights that would become core beliefs of the coming centuries. He did not, as legend would tell, murmer "eppur si muove" ("and yet it moves"), but neither did he relent on every point: he continued to refuse to confess to deceiving the censors in procuring his license, or to say he had been "a bad Catholic". And the curia itself was clearly divided at the highest ranks: Of ten judges, only seven actually signed the sentence. Among the abstainers was Francesco Cardinal Barberini, the pope's brother, who seems to have played an important role behind the scenes in tempering His Holiness's wrath, and in mitigating Galileo's sentence.

And he was successful. Again, the legend cries out for a martyr, but Galileo's three-year prison sentence was immediately commuted to house arrest, and he was even allowed to pass his penitential psalms on to his daughter, Sister Maria Celeste, a Carmelite nun. The next years would bring further blows: his daughter's death, his own blindness, illnesses, constant surveillance of his mail and his villa in the small town of Arcetri, outside of Florence. And yet, in those declining years Galileo composed his final dialogue, *The Discourses on Two New Sciences*, the most brilliant and influential of any of his works, and smuggled it out for publication in Holland in 1638. With it, the initiative in scientific advance would pass out of Catholic Europe into the protestant north. The book of medieval thought was well and truly closed, and the scientific revolution was being roughed out. Galileo himself died on January 8, 1642, aged 78 years. In December of that same year, in distant England, Isaac Newton was born, who would inscribe the great Italian's mathematical order onto the farthest mote of the heavens, and so help to create, for good or ill, the world we know and inhabit today.